ΤΕΧΝΟΛΟΓΙΚΟ ΕΚΠΑΙΔΕΥΤΙΚΟ ΙΔΡΥΜΑ ΠΕΙΡΑΙΑ
ΣΧΟΛΗ ΤΕΧΝΟΛΟΓΙΚΩΝ ΕΦΑΡΜΟΓΩΝ
ΤΜΗΜΑ ΜΗΧΑΝΟΛΟΓΙΑΣ

ΘΕΜΑ: ΣΧΕΔΙΑΣΜΟΣ ΚΑΙ ΚΑΤΑΣΚΕΥΗ ΑΝΥΨΩΤΙΚΟΥ ΜΗΧΑΝΗΜΑΤΟΣ ΜΟΤΟΣΥΚΛΕΤΩΝ

ΠΤΥΧΙΑΚΗ ΕΡΓΑΣΙΑ

Των
Πανοτόπουλου Χαράλαμπου
Μπουλουγούρα Παναγιώτη

Επιβλέπων καθηγητής
Δρ. Στεργίου Κωνσταντίνος

Πειραιάς 2013

ΠΙΝΑΚΑΣ ΠΕΡΙΕΧΟΜΕΝΩΝ

«ΕΙΣΑΓΩΓΗ»

Η χρήση μηχανών για την ανύψωση φορτίων κατά τη διάρκεια οικοδομικών εργασιών ξεκινάει τουλάχιστον στη ρωμαϊκή εποχή. Ο Ρωμαίος αρχιτέκτονας και μηχανικός Βετρούβιος περιέγραψε τον 1ο αιώνα π.Χ. ανυψωτικές εξέδρες στις οποίες χρησιμοποιούνταν τροχαλίες και βαρούλκα ή "εργάτες" που κινούνταν με τη μυϊκή δύναμη ανθρώπων ή ζώων ή με τη δύναμη του νερού.

Η ατμοκίνηση χρησιμοποιήθηκε σε τέτοιες συσκευές στην Αγγλία περίπου το 1800. Στις αρχές του 19ου αιώνα παρουσιάστηκε ένας υδραυλικός ανελκυστήρας του οποίου η εξέδρα ήταν στερεωμένη σε ένα έμβολο που κινούνταν μέσα σε έναν κύλινδρο βυθισμένο στο έδαφος κάτω από το φρεάτιο και σε βάθος ίσο με το ύψος του φρεατίου. Μια ατμοκίνητη αντλία ασκούσε πίεση στο υγρό, μέσα στον κύλινδρο. Αργότερα, χρησιμοποιήθηκε ένας συνδυασμός τροχαλιών για τον πολλαπλασιασμό της διαδρομής του οχήματος και τη μείωση της βύθισης του εμβόλου. Σε όλες αυτές τις συσκευές χρησιμοποιούνταν αντίβαρα για την εξισορρόπηση του απόβαρου του οχήματος κι έτσι απαιτούνταν ισχύς αρκετή μόνο για την ανύψωση του ωφέλιμου φορτίου.

Μέχρι τα μέσα της δεκαετίας του 1850, οι αρχές αυτές χρησιμοποιούνταν κυρίως για την ανύψωση φορτίων. Λόγω της μικρής αξιοπιστίας των (γενικά κανάβινων) σχοινιών που χρησιμοποιούνταν εκείνη την εποχή, οι ανυψωτικές αυτές εξέδρες δεν μπορούσαν να χρησιμοποιηθούν για την μεταφορά επιβατών. Το 1853 ο Αμερικανός Ελίσα Γκρέιβις Όπις (Elisha Graves Otis) παρουσίασε μια ασφαλιστική διάταξη και το γεγονός αυτό σήμαινε τη γέννηση του επιβατικού ανελκυστήρα. Η συσκευή του Όπις περιλάμβανε μιά διάταξη αρπάγης που σφηνωνόταν στους οδηγούς, επάνω στους οποίους κινούνταν το όχημα, μόλις έπαυε να ασκείται δύναμη στο σχοινί ανύψωσης. Ο πρώτος επιβατικός ανελκυστήρας τέθηκε σε λειτουργία στη Νέα Υόρκη το 1857. Ήταν ατμοκίνητος, ανέβαινε σε ύψος πέντε ορόφων σε λιγότερο από ένα λεπτό και αποτέλεσε μια αναμφισβήτητη επιτυχία.

Το 1889 χρησιμοποιήθηκε για πρώτη φορά ο ηλεκτροκινητήρας. Στην εγκατάσταση αυτή ένας ηλεκτροκινητήρας έδινε κίνηση σε τύμπανο περιέλιξης στο υπόγειο του κτιρίου. Η εισαγωγή του ηλεκτρισμού οδήγησε σε δύο ακόμη εξελίξεις : το 1894 παρουσιάστηκαν τα χειριστήρια με κουμπιά και το 1895 εκτέθηκε στην Αγγλία μια ανυψωτική συσκευή στην οποία η ισχύς παρέχονταν σε μια αυλακωτή τροχαλία στην κορυφή του φρεατίου. Τα βάρη του θαλάμου και του αντίβαρου αρκούσαν για την εξασφάλιση έλξης. Το 1904 επιτεύχθηκε η λειτουργία χωρίς μειωτήρα, με την άμεση προσαρμογή της κινητήριας τροχαλίας στον άξονα του δρομέα του ηλεκτροκινητήρα και με την καινοτομία αυτή επιτεύχθηκε πρακτικά απεριόριστη ταχύτητα.

Με την αύξηση του ύψους των κτιρίων, οι ταχύτητες των ανελκυστήρων αυξήθηκαν ως τα 365 μέτρα ανά λεπτό σε εγκαταστάσεις εξπρές, όπως αυτές που προορίζονταν για τους τελευταίους ορόφους του Empire State Building (1931) και έφτασαν στα 549 μέτρα

ανά λεπτό στο John Hancock Center στο Σικάγο το 1970 και 610 μέτρα ανά λεπτό στο κτίριο "Λιακάδα 60 (Αικεμπουκούρο, Τόκιο) το 1978.

Μια αρχική προσπάθεια ελαχιστοποίησης της απώλειας επιφάνειας δαπέδου στις εγκαταστάσεις ανελκυστήρων σε υψηλά κτίρια στηρίχθηκε στην ιδέα του διωρόφου ανελκυστήρα που δοκιμάστηκε για πρώτη φορά το 1932. Κάθε ανελκυστήρας αποτελούνταν από δύο θαλάμους, συναρμολογημένους ο ένας επάνω από τον άλλο. Οι δύο αυτοί θάλαμοι λειτουργούσαν ως μία μονάδα, εξυπηρετώντας δύο ορόφους σε κάθε στάση. (Στη χώρα μας η διάταξη αυτή απαγορεύεται από τους σχετικούς κανονισμούς του Υπουργείου Βιομηχανίας). Αυτόματοι διώροφοι ανελκυστήρες λειτουργούν από το 1971 στο Μέγαρο Time-Life στο Σικάγο και έχουν υιοθετηθεί σε πολλά άλλα κτίρια στον κόσμο.

Στη σύγχρονη εποχή, με τη ραγδαία εξέλιξη της τεχνολογίας, οι ανάγκες για ανύψωση πολλαπλασιάστηκαν, εξειδικεύτηκαν και έγιναν πιο περίπλοκες. Για παράδειγμα η ανύψωση προς επισκευή οχημάτων, περιλαμβάνει την ανάγκη για ανύψωση του αντικειμένου, παράλληλα με τη δημιουργία κατάλληλων και ασφαλών συνθηκών εργασίας για τους επισκευαστές. Με το σχεδιασμό και την κατασκευή μιας τέτοιας μηχανής ανύψωσης μοτοσυκλετών θα ασχοληθούμε στην εργασία αυτή. Για το σκοπό αυτό θα χρησιμοποιηθούν σύγχρονες τεχνικές της επιστήμης του «Σχεδιασμού Κατασκευών» καθώς και σύγχρονα, τρισδιάστατα προγράμματα ηλεκτρονικής σχεδίασης και ελέγχου της κατασκευής.

ΚΕΦΑΛΑΙΟ ΠΡΩΤΟ «ΣΧΕΔΙΑΣΜΟΣ ΤΗΣ ΚΑΤΑΣΚΕΥΗΣ»

1.1. Διατύπωση του προβλήματος

1.1.1.Πίνακες προδιαγραφών

Πτυχιακή εργασία Πανοτόπουλου Χαράλαμπου Μπουλουγούρα Παναγιώτη	**ΠΙΝΑΚΑΣ ΠΡΟΔΙΑΓΡΑΦΩΝ** Ανυψωτικού μηχανήματος μοτοσικλετών		Έκδοση 14/09/2011 Σελίδα | 1
Μεταβολή	**ΑΕ**	**Προδιαγραφές**	**Υπεύθυνος**
14/09/2011	A	Διαστάσεις ≤ 2700 mm x 800 mm	
14/09/2011	A	Μέγιστο ύψος ανέλκυσης ≈ 800 mm	
14/09/2011	A	Ελάχιστο ύψος ανέλκυσης ≈ 200 mm	
14/09/2011	A	Βάρος Κατασκευής ≤ 180 Kgr	
14/09/2011	A	Βάρος Ανέλκυσης ≥ 500 Kgr	
14/09/2011	A	Δυνατότητα πάκτωσης	
14/09/2011	A	Ισχύς ≤ 3 kW	
14/09/2011	A	Δυνατότητα εναλλακτικής πηγής ενέργειας	
14/09/2011	A	Αντοχή σε χημική προσβολή	
14/09/2011	A	Κατασκευή ανθεκτική σε υψηλές θερμοκρασίες	
14/09/2011	A	Αντιολισθητική επιφάνεια εργασίας	
14/09/2011	A	Σημεία στήριξης – συγκράτησης μοτοσικλέτας	
14/09/2011	E	Δυνατότητα συγκράτησης της μοτοσικλέτας από σημεία που θα επιτρέπουν αφαίρεση τροχών και αναρτήσεων	
14/09/2011	A	Δυνατότητα χειροκίνητης διακοπής λειτουργίας	
14/09/2011	A	Σχεδιασμός ασφαλής προς το χρήστη	
14/09/2011	E	Δυνατότητα επείγουσας τηλεφωνικής κλήσης σε περίπτωση ατυχήματος	
14/09/2011	A	Χρωματισμός φιλικός προς το χρήστη	

Πτυχιακή εργασία Πανοτόπουλου Χαράλαμπου Μπουλουγούρα Παναγιώτη	ΠΙΝΑΚΑΣ ΠΡΟΔΙΑΓΡΑΦΩΝ Ανυψωτικού μηχανήματος μοτοσικλετών		Έκδοση 14/09/2011 Σελίδα | 1
Μεταβολή	**Α Ε**	**Προδιαγραφές**	**Υπεύθυνος**
14/09/2011	Α	Χώρος προσωρινής εναπόθεσης εργαλείων	
14/09/2011	Ε	Φουτουριστικός σχεδιασμός	
14/09/2011	Α	Εύκολος καθαρισμός	
14/09/2011	Ε	Εγκατάσταση ενσωματωμένου φωτισμού	
14/09/2011	Α	Προδιαγραφές ασφαλείας EN1493:2010, EN1495:1997+A2:2009, EN1570:1998+A2:2009	
14/09/2011	Α	Ευελιξία στη διαμόρφωση της κατασκευής	
14/09/2011	Ε	Ευκολία συναρμολόγησης - αποσυναρμολόγησης	
14/09/2011	Α	Ευκολία μεταφοράς - τοποθέτησης	
14/09/2011	Ε	Χαμηλό κόστος συντήρησης - επισκευής	
14/09/2011	Ε	Δυνατότητα συλλογής και αυτόματης απομάκρυνσης μεταχειρισμένων υγρών	
14/09/2011	Ε	Κόστος παραγωγής έως 700 €/τεμάχιο	
14/09/2011	Α	Δυνατότητα παραγωγής ενός (1) τεμαχίου ανά εβδομάδα	
	Αντικαθιστά έκδοση από		

Μεταβολή	Α Ε	Προδιαγραφές	Υπεύθυνος
14/09/2011	A	Διαστάσεις ≤ 2700 mm x 800 mm	
14/09/2011	A	Μέγιστο ύψος ανέλκυσης ≈ 800 mm	
14/09/2011	A	Ελάχιστο ύψος ανέλκυσης ≈ 300 mm	
17/09/2011	E	Ευθύγραμμη κατακόρυφη ανύψωση	
17/09/2011	A	Αποκλεισμός εκτροπής στον οριζόντιο άξονα	
17/09/2011	A	Ολικός χρόνος ανύψωσης 30 sec	
14/09/2011	A	Βάρος Κατασκευής ≤ 180 Kgr	
14/09/2011	A	Βάρος Ανέλκυσης ≥ 500 Kgr	
14/09/2011	A	Δυνατότητα πάκτωσης	
14/09/2011	A	Ισχύς ≤ 3 kW	
14/09/2011	A	Δυνατότητα εναλλακτικής πηγής ενέργειας	
14/09/2011	A	Αντοχή σε χημική προσβολή	
14/09/2011	A	Κατασκευή ανθεκτική σε υψηλές θερμοκρασίες	
14/09/2011	A	Αντιολισθητική επιφάνεια εργασίας	
14/09/2011	A	Σημεία στήριξης – συγκράτησης μοτοσικλέτας	
14/09/2011	E	Δυνατότητα συγκράτησης της μοτοσικλέτας από σημεία που θα επιτρέπουν αφαίρεση τροχών και αναρτήσεων	
14/09/2011	A	Δυνατότητα χειροκίνητης διακοπής λειτουργίας	
14/09/2011	A	Σχεδιασμός ασφαλής προς το χρήστη	
14/09/2011	E	Δυνατότητα επείγουσας τηλεφωνικής κλήσης σε περίπτωση ατυχήματος	
14/09/2011	A	Χρωματισμός φιλικός προς το χρήστη	

14/09/2011	A	Χώρος προσωρινής εναπόθεσης εργαλείων
14/09/2011	E	Φουτουριστικός σχεδιασμός
14/09/2011	A	Εύκολος καθαρισμός
14/09/2011	E	Εγκατάσταση ενσωματωμένου φωτισμού
14/09/2011	A	Προδιαγραφές ασφαλείας EN1493:2010, EN1495:1997+A2:2009, EN1570:1998+A2:2009
17/09/2011	A	Πιστοποίηση ISO
17/09/2011	A	Πιστοποιητικό δοκιμών κατασκευαστή
14/09/2011	A	Ευελιξία στη διαμόρφωση της κατασκευής
14/09/2011	E	Ευκολία συναρμολόγησης - αποσυναρμολόγησης
14/09/2011	A	Ευκολία μεταφοράς – τοποθέτησης
17/09/2011	A	Επίπεδο θορύβου ≤ 80dB
17/09/2011	A	Χαμηλό επίπεδο κραδασμών
14/09/2011	E	Χαμηλό κόστος συντήρησης - επισκευής
17/09/2011	A	Χρήση ανακυκλώσιμων αναλώσιμων υλικών
14/09/2011	E	Δυνατότητα συλλογής και αυτόματης απομάκρυνσης μεταχειρισμένων υγρών
14/09/2011	E	Κόστος παραγωγής έως 700 €/τεμάχιο
14/09/2011	A	Δυνατότητα παραγωγής ενός (1) τεμαχίου ανά εβδομάδα
	Αντικαθιστά έκδοση από 14/09/2011	

1.1.2.Αφαιρετική διαδικασία

1° – 2° βήμα αφαίρεσης

- Διαστάσεις ≤ 210 mm x 80 mm
- Μέγιστο ύψος ανέλκυσης ≈ 800 mm
- Ελάχιστο ύψος ανέλκυσης ≈ 200 mm
- Αποκλεισμός εκτροπής στον οριζόντιο άξονα
- Ολικός χρόνος ανύψωσης 30 sec
- Βάρος Κατασκευής ≤ 180 Kgr
- Βάρος Ανέλκυσης ≥ 500 Kgr
- Δυνατότητα πάκτωσης
- Ισχύς ≤ 3 kW
- Δυνατότητα εναλλακτικής πηγής ενέργειας
- Σημεία στήριξης – συγκράτησης μοτοσικλέτας
- Δυνατότητα χειροκίνητης διακοπής λειτουργίας
- Σχεδιασμός ασφαλής προς το χρήστη
- Προδιαγραφές ασφαλείας EN1495:1997+A2:2009 & EN1570:1998+A2:2009
- Επίπεδο θορύβου ≤ 80dB
- Χαμηλό επίπεδο κραδασμών

3° βήμα αφαίρεσης

- Περιορισμένο βάρος – διαστάσεις
- Ικανή ισχύς
- Εναλλακτική πηγή ενέργειας
- Ικανοποιητικό βάρος ανέλκυσης
- Ικανοποιητικό μέγιστο – ελάχιστο ύψος ανέλκυσης
- Ασφαλεια εργασίας κατά τη χρήση
- Χαμηλό επίπεδο θορύβου – κραδασμών

4° βήμα αφαίρεσης

- Περιορισμένο βάρος – διαστάσεις
- Ικανή ισχύς από εναλλακτικές πηγές ενέργειας, για την επίτευξη ικανοποιητικών μεγεθών ανέλκυσης – καθέλκυσης
- Ασφάλεια και εργονομία κατά την εργασία

5° βήμα αφαίρεσης

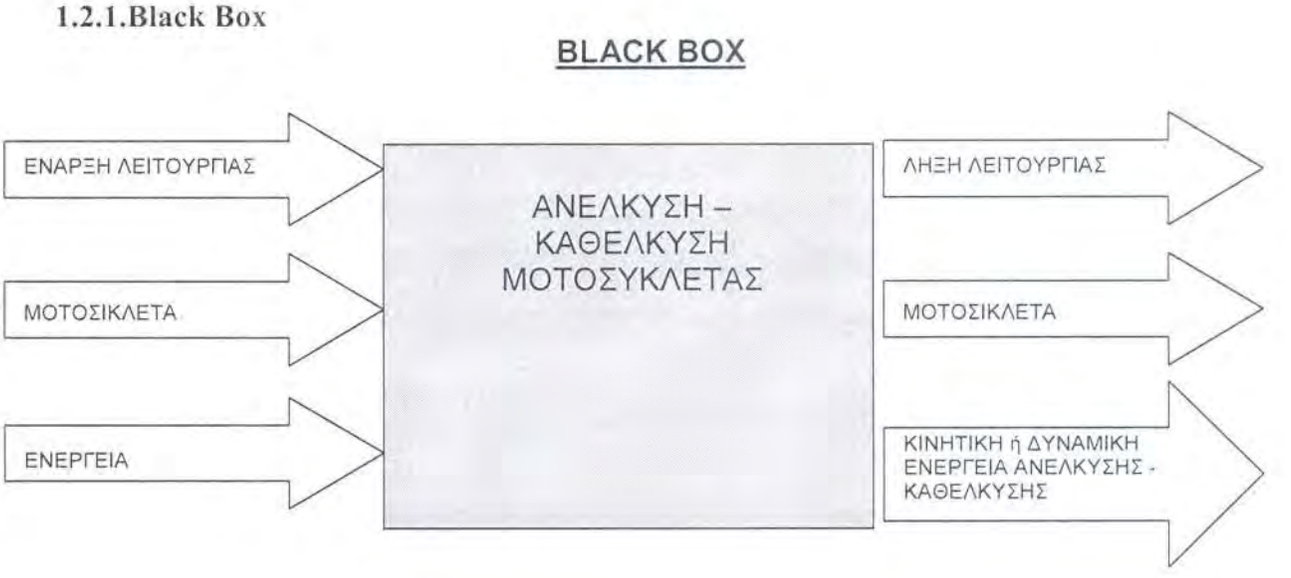
- Ανέλκυση – καθέλκυση μοτοσικλέτας με ασφαλή και εργονομικό τρόπο.

1.1.3.Διατύπωση του προβλήματος

Η αφαιρετική διαδικασία είχε ως αποτέλεσμα την πιο απλουστευμένη διατύπωση του προβλήματος η οποία είναι: «Ανέλκυση – καθέλκυση μοτοσικλέτας με ασφαλή και εργονομικό τρόπο».

1.2. Δομή λειτουργίας

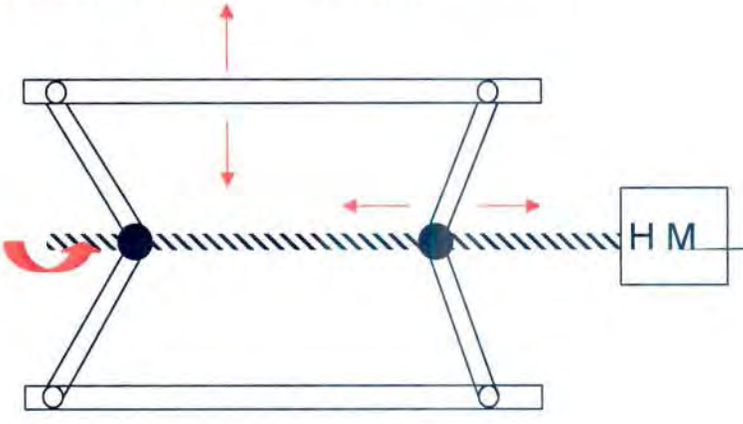
1.2.1.Black Box



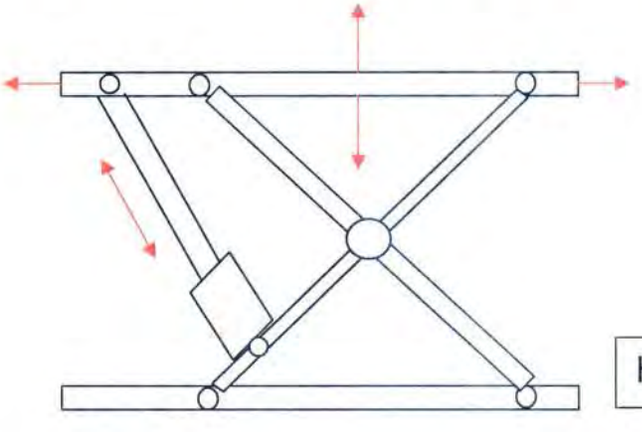
1.2.2.Δομή λειτουργίας

1.3. Διαισθητικές λύσεις (Brainstorming)

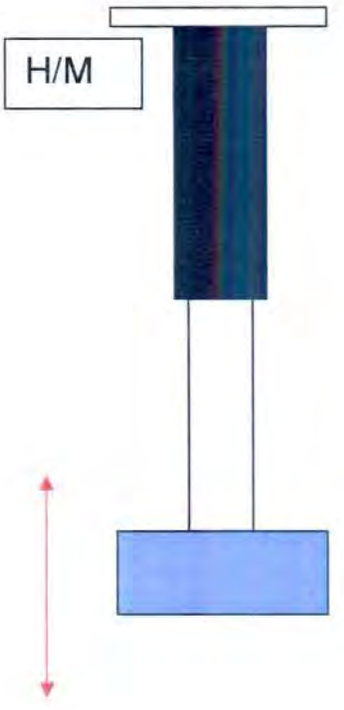
Κοχλιωτός άξονας περιστρεφόμενος από ηλεκτρικό μοτέρ και αρθρωτά στηρίγματα
Ευθύγραμμη κατακόρυφη παλινδρομική κίνηση



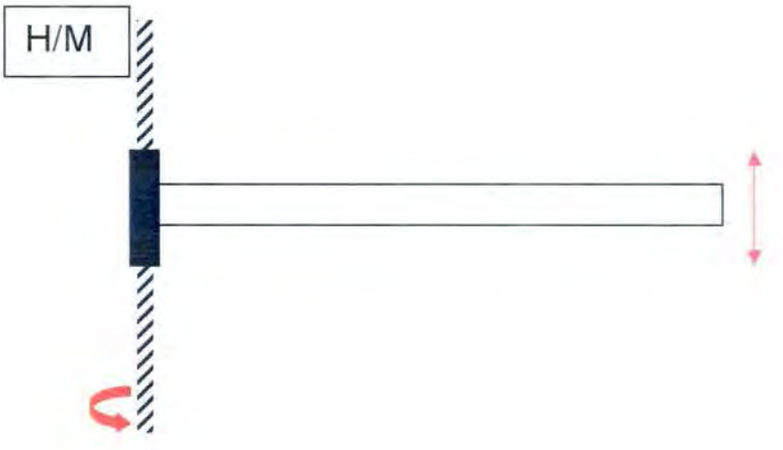
Υδραυλική μπουκάλα με ηλεκτρικό μοτέρ και διαστατροπημένα μονόκομματα στηρίγματα
Παλινδρομική συνδυαστική κίνηση στους άξονες χ και ψ



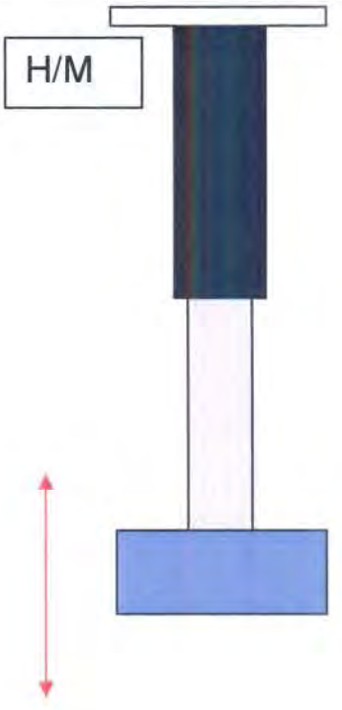
3. Ηλεκτρομαγνήτης οροφής, κινούμενος από υδραυλική μπουκάλα με ηλεκτρικό μοτέρ. Ευθύγραμμη κατακόρυφη παλινδρομική κίνηση.



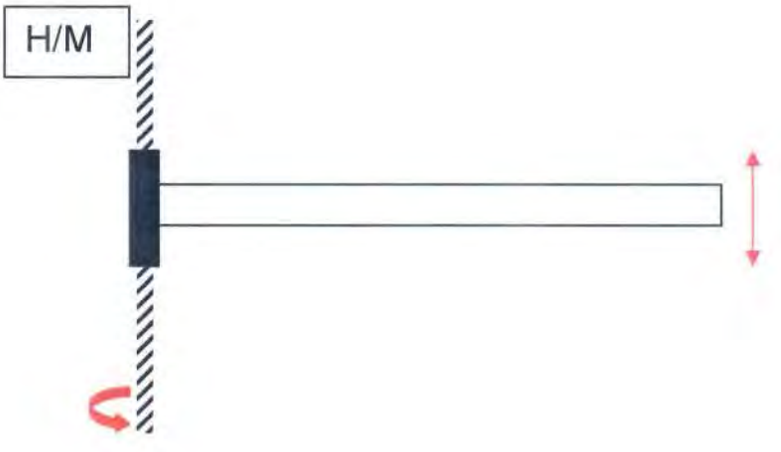
4. Κοχλιωτός άξονας περιστρεφόμενος από ηλεκτρικό μοτέρ και μονόπλευρη στήριξη απ' ευθείας στο τραπέζι εργασίας. Ευθύγραμμη κατακόρυφη παλινδρομική κίνηση.



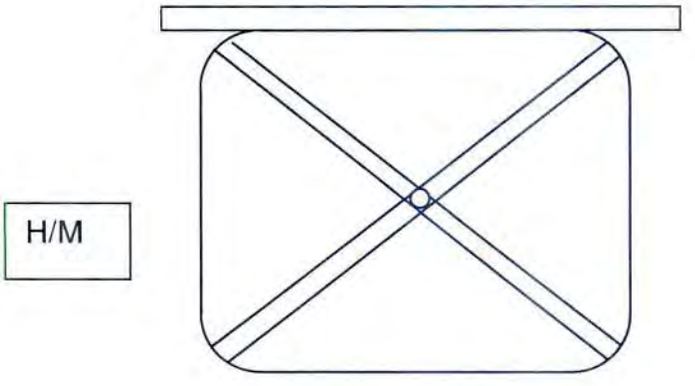
3. Ηλεκτρομαγνήτης οροφής, κινούμενος από υδραυλική μπουκάλα με ηλεκτρικό μοτέρ. Ευθύγραμμη κατακόρυφη παλινδρομική κίνηση.



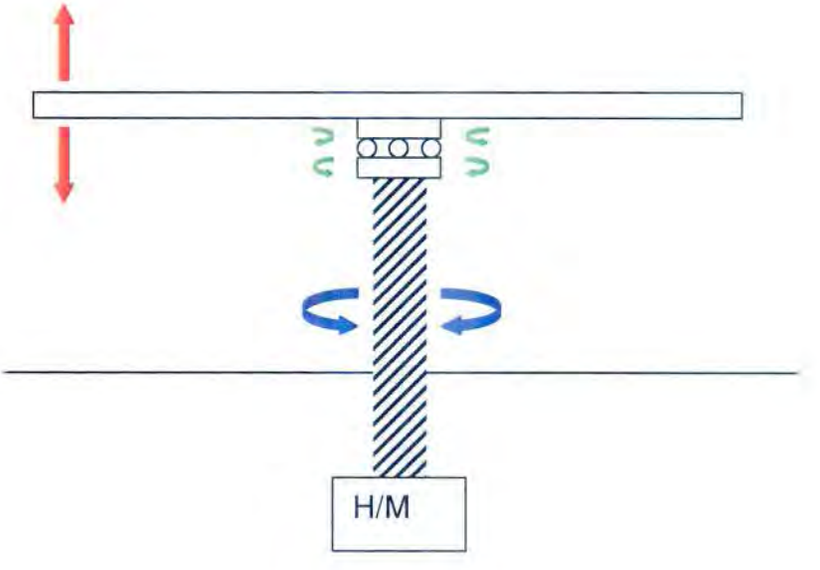
4. Κοχλιωτός άξονας περιστρεφόμενος από ηλεκτρικό μοτέρ και μονόπλευρη στήριξη απ' ευθείας στο τραπέζι εργασίας. Ευθύγραμμη κατακόρυφη παλινδρομική κίνηση.



8. Αερόσακος, με διασταυρούμενα, μονοκόμματα στηρίγματα και παροχή αέρα από ηλεκτρικό αεροσυμπιεστή.



9. Τραπέζι εργασίας βασισμένο μέσω περιστρεφόμενης βάσης, σε κεντρικό κοχλιωτό άξονα, βυθιζόμενο στο έδαφος.



1.4. Λύσεις με μήτρα ταξινόμησης

ΜΗΤΡΑ ΤΑΞΙΝΟΜΗΣΗΣ

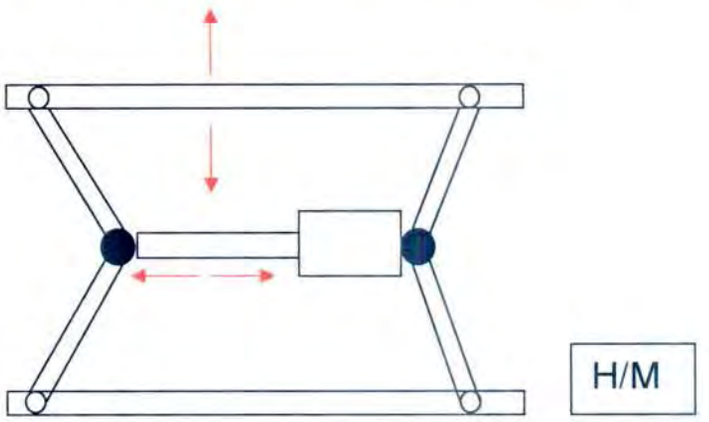
ΕΝΕΡΓΕΙΑ			ΗΛΕΚΤΡΙΚΗ				ΜΗΧΑΝΙΚΗ			
ΜΕΣΟ ΑΝΥΨΩΣΗΣ			ΠΝΕΥΜΑΤΙΚΟ	ΥΔΡΑΥΛΙΚΟ	ΤΡΟΧΑΛΙΑ	ΚΟΧΛΙΩΤΟΣ ΑΞΟΝΑΣ	ΠΝΕΥΜΑΤΙΚΟ	ΥΔΡΑΥΛΙΚΟ	ΤΡΟΧΑΛΙΑ	ΚΟΧΛΙΩΤΟΣ ΑΞΟΝΑΣ
ΔΙΕΥΘΥΝΣΗ ΚΙΝΗΣΗΣ ΣΤΟΙΧΕΙΟΥ ΑΝΥΨΩΣΗΣ	ΕΙΔΟΣ ΚΙΝΗΣΗΣ ΣΤΟΙΧΕΙΟΥ ΑΝΥΨΩΣΗΣ	ΤΡΟΠΟΣ ΣΤΗΡΙΞΗΣ								
ΕΥΘΥΓΡΑΜΜΗ	ΠΑΛΙΝΔΡΟΜΙΚΗ	ΑΠΕΥΘΕΙΑΣ ΣΤΟ ΣΤΟΙΧΕΙΟ ΑΝΕΛΚΥΣΗΣ								
		ΑΡΘΡΩΤΑ ΣΤΗΡΙΓΜΑΤΑ								
		ΠΑΚΤΩΣΗ								
		ΜΟΝΟΚΟΜΜΑΤΑ ΔΙΑΣΤΑΥΡΟΥΜΕΝΑ ΣΤΗΡΙΓΜΑΤΑ								
		ΜΟΝΟΠΛΕΥΡΗ ΣΤΗΡΙΞΗ ΣΕ ΚΟΧΛΙΩΤΟ ΑΞΟΝΑ								
		ΜΟΝΟΚΟΜΜΑΤΑ ΠΑΡΑΛΛΗΛΑ ΣΤΗΡΙΓΜΑΤΑ								
	ΣΥΝΕΧΗΣ	ΑΠΕΥΘΕΙΑΣ ΣΤΟ ΣΤΟΙΧΕΙΟ ΑΝΕΛΚΥΣΗΣ	40	41						
		ΑΡΘΡΩΤΑ ΣΤΗΡΙΓΜΑΤΑ	10	11			12	13		
		ΠΑΚΤΩΣΗ	21	3			22	23		
		ΜΟΝΟΚΟΜΜΑΤΑ ΔΙΑΣΤΑΥΡΟΥΜΕΝΑ ΣΤΗΡΙΓΜΑΤΑ	15	2			16	17		
		ΜΟΝΟΠΛΕΥΡΗ ΣΤΗΡΙΞΗ ΣΕ ΚΟΧΛΙΩΤΟ ΑΞΟΝΑ	26, 31	27, 32			28, 33	29, 34		
		ΜΟΝΟΚΟΜΜΑΤΑ ΠΑΡΑΛΛΗΛΑ ΣΤΗΡΙΓΜΑΤΑ	18	19			6	20		

ΕΝΕΡΓΕΙΑ			ΗΛΕΚΤΡΙΚΗ				ΜΗΧΑΝΙΚΗ			
ΜΕΣΟ ΑΝΥΨΩΣΗΣ			ΠΝΕΥΜΑΤΙΚΟ	ΥΔΡΑΥΛΙΚΟ	ΤΡΟΧΑΛΙΑ	ΚΟΧΛΙΩΤΟΣ ΑΞΟΝΑΣ	ΠΝΕΥΜΑΤΙΚΟ	ΥΔΡΑΥΛΙΚΟ	ΤΡΟΧΑΛΙΑ	ΚΟΧΛΙΩΤΟΣ ΑΞΟΝΑΣ
ΔΙΕΥΘΥΝΣΗ ΚΙΝΗΣΗΣ ΣΤΟΙΧΕΙΟΥ ΑΝΥΨΩΣΗΣ	ΕΙΔΟΣ ΚΙΝΗΣΗΣ ΣΤΟΙΧΕΙΟΥ ΑΝΥΨΩΣΗΣ	ΤΡΟΠΟΣ ΣΤΗΡΙΞΗΣ								
ΤΡΙΣΔΙΑΣΤΑΤΗ	ΠΑΛΙΝΔΡΟΜΙΚΗ	ΑΠΕΥΘΕΙΑΣ ΣΤΟ ΣΤΟΙΧΕΙΟ ΑΝΕΛΚΥΣΗΣ								
		ΑΡΘΡΩΤΑ ΣΤΗΡΙΓΜΑΤΑ								
		ΠΑΚΤΩΣΗ								
		ΜΟΝΟΚΟΜΜΑΤΑ ΔΙΑΣΤΑΥΡΟΥΜΕΝΑ ΣΤΗΡΙΓΜΑΤΑ								
		ΜΟΝΟΠΛΕΥΡΗ ΣΤΗΡΙΞΗ ΣΕ ΚΟΧΛΙΩΤΟ ΑΞΟΝΑ								
		ΜΟΝΟΚΟΜΜΑΤΑ ΠΑΡΑΛΛΗΛΑ ΣΤΗΡΙΓΜΑΤΑ								
	ΣΥΝΕΧΗΣ	ΑΠΕΥΘΕΙΑΣ ΣΤΟ ΣΤΟΙΧΕΙΟ ΑΝΕΛΚΥΣΗΣ								
		ΑΡΘΡΩΤΑ ΣΤΗΡΙΓΜΑΤΑ	38				39			
		ΠΑΚΤΩΣΗ								
		ΜΟΝΟΚΟΜΜΑΤΑ ΔΙΑΣΤΑΥΡΟΥΜΕΝΑ ΣΤΗΡΙΓΜΑΤΑ	8				35			
		ΜΟΝΟΠΛΕΥΡΗ ΣΤΗΡΙΞΗ ΣΕ ΚΟΧΛΙΩΤΟ ΑΞΟΝΑ								
		ΜΟΝΟΚΟΜΜΑΤΑ ΠΑΡΑΛΛΗΛΑ ΣΤΗΡΙΓΜΑΤΑ	36				37			

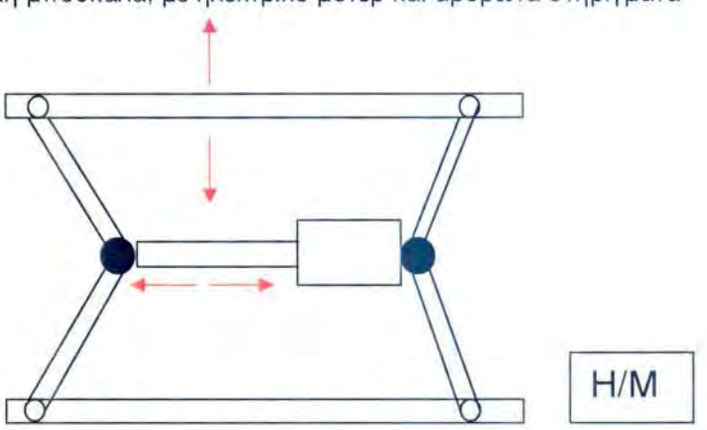
ΕΝΕΡΓΕΙΑ			ΗΛΕΚΤΡΙΚΗ				ΜΗΧΑΝΙΚΗ			
ΜΕΣΟ ΑΝΥΨΩΣΗΣ			ΠΝΕΥΜΑΤΙΚΟ	ΥΔΡΑΥΛΙΚΟ	ΤΡΟΧΑΛΙΑ	ΚΟΧΛΙΩΤΟΣ ΑΞΟΝΑΣ	ΠΝΕΥΜΑΤΙΚΟ	ΥΔΡΑΥΛΙΚΟ	ΤΡΟΧΑΛΙΑ	ΚΟΧΛΙΩΤΟΣ ΑΞΟΝΑΣ
ΔΙΕΥΘΥΝΣΗ ΚΙΝΗΣΗΣ ΣΤΟΙΧΕΙΟΥ ΑΝΥΨΩΣΗΣ	ΕΙΔΟΣ ΚΙΝΗΣΗΣ ΣΤΟΙΧΕΙΟΥ ΑΝΥΨΩΣΗΣ	ΤΡΟΠΟΣ ΣΤΗΡΙΞΗΣ								
ΠΕΡΙΣΤΡΟΦΙΚΗ	ΠΑΛΙΝΔΡΟΜΙΚΗ	ΑΠΕΥΘΕΙΑΣ ΣΤΟ ΣΤΟΙΧΕΙΟ ΑΝΕΛΚΥΣΗΣ								
		ΑΡΘΡΩΤΑ ΣΤΗΡΙΓΜΑΤΑ								
		ΠΑΚΤΩΣΗ								
		ΜΟΝΟΚΟΜΜΑΤΑ ΔΙΑΣΤΑΥΡΟΥΜΕΝΑ ΣΤΗΡΙΓΜΑΤΑ								
		ΜΟΝΟΠΛΕΥΡΗ ΣΤΗΡΙΞΗ ΣΕ ΚΟΧΛΙΩΤΟ ΑΞΟΝΑ								
		ΜΟΝΟΚΟΜΜΑΤΑ ΠΑΡΑΛΛΗΛΑ ΣΤΗΡΙΓΜΑΤΑ								
	ΣΥΝΕΧΗΣ	ΑΠΕΥΘΕΙΑΣ ΣΤΟ ΣΤΟΙΧΕΙΟ ΑΝΕΛΚΥΣΗΣ				9				
		ΑΡΘΡΩΤΑ ΣΤΗΡΙΓΜΑΤΑ				1				14
		ΠΑΚΤΩΣΗ			5	24				
		ΜΟΝΟΚΟΜΜΑΤΑ ΔΙΑΣΤΑΥΡΟΥΜΕΝΑ ΣΤΗΡΙΓΜΑΤΑ								
		ΜΟΝΟΠΛΕΥΡΗ ΣΤΗΡΙΞΗ ΣΕ ΚΟΧΛΙΩΤΟ ΑΞΟΝΑ				4, 7				25, 30
		ΜΟΝΟΚΟΜΜΑΤΑ ΠΑΡΑΛΛΗΛΑ ΣΤΗΡΙΓΜΑΤΑ								

ΛΥΣΕΙΣ ΑΠΟ ΜΗΤΡΑ ΤΑΞΙΝΟΜΗΣΗΣ

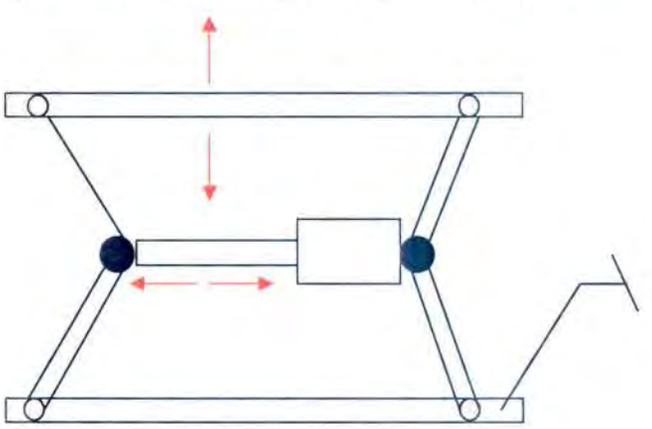
10. Πνευματική μπουκάλα, με ηλεκτρικό μοτέρ και αρθρωτά στηρίγματα



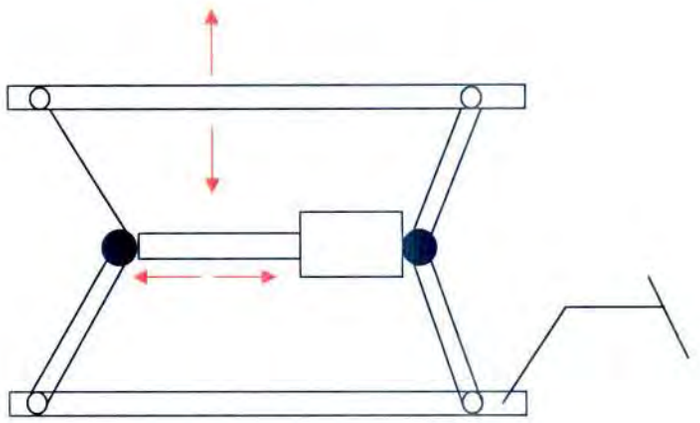
11. Υδραυλική μπουκάλα, με ηλεκτρικό μοτέρ και αρθρωτά στηρίγματα



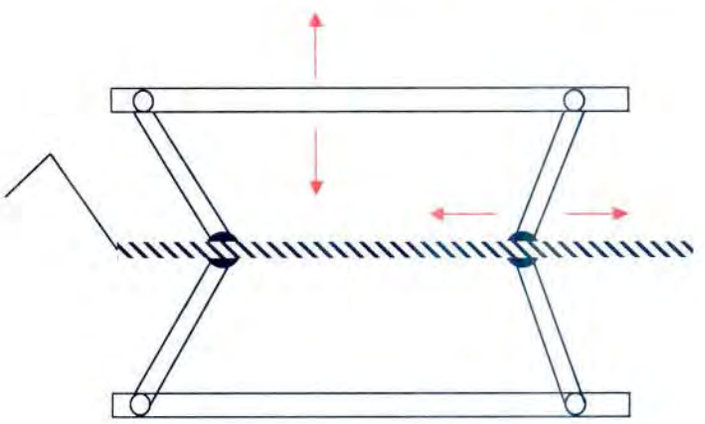
12. Πνευματική μπουκάλα, ποδοκίνητη, με αρθρωτά στηρίγματα



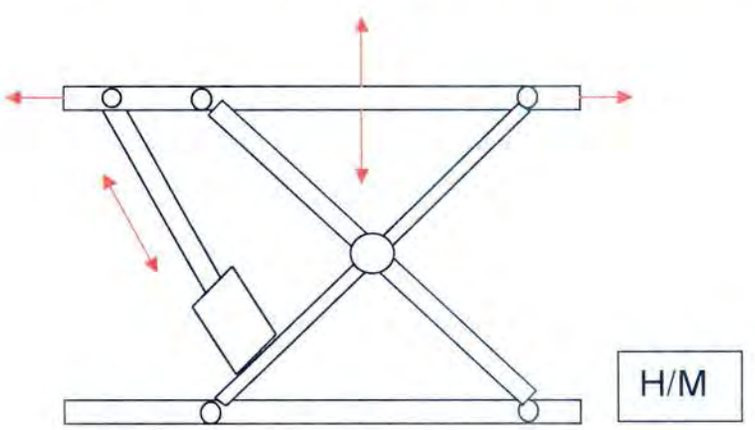
13. Υδραυλική μπουκάλα, ποδοκίνητη, με αρθρωτά στηρίγματα



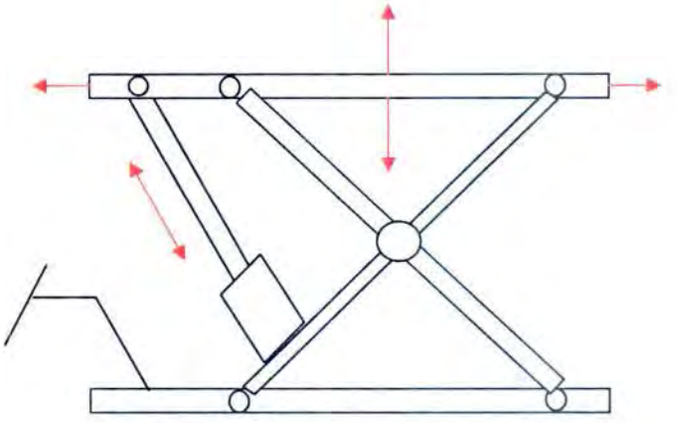
14. Κοχλιωτός άξονας, χειροστρεφόμενος, με αρθρωτά στηρίγματα



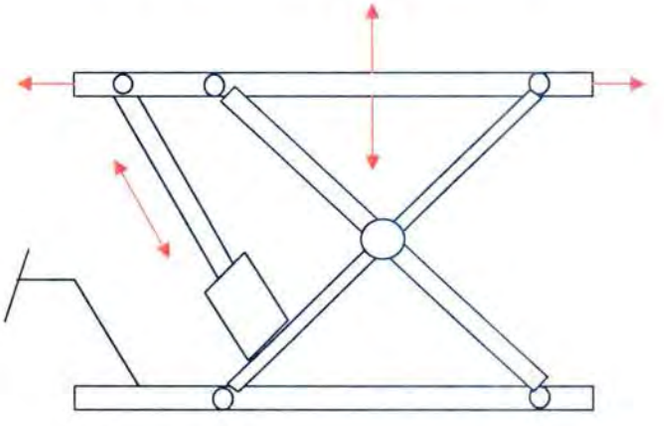
15. Πνευματική μπουκάλα με ηλεκτρικό μοτέρ και διασταυρούμενα μονοκόμματα στηρίγματα



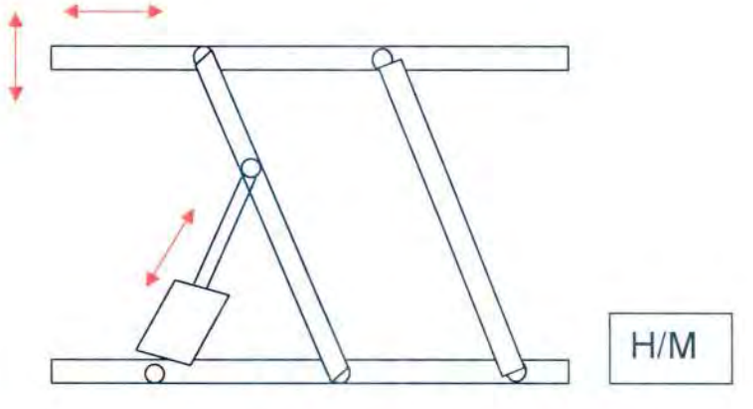
16. Πνευματική μπουκάλα, ποδοκίνητη, με διασταυρούμενα μονοκόμματα στηρίγματα



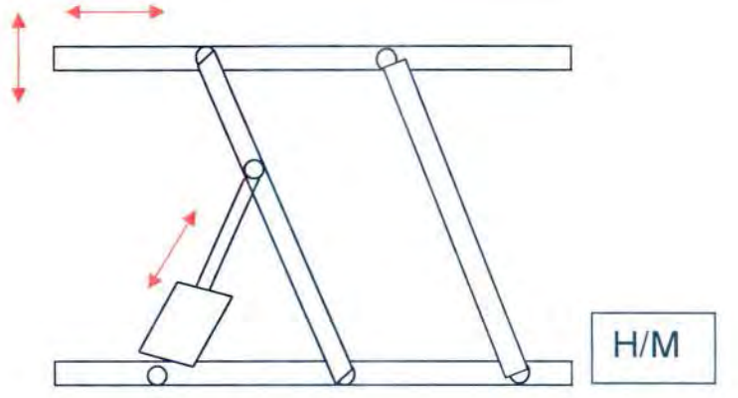
17. Υδραυλική μπουκάλα, ποδοκίνητη, με διασταυρούμενα μονοκόμματα στηρίγματα



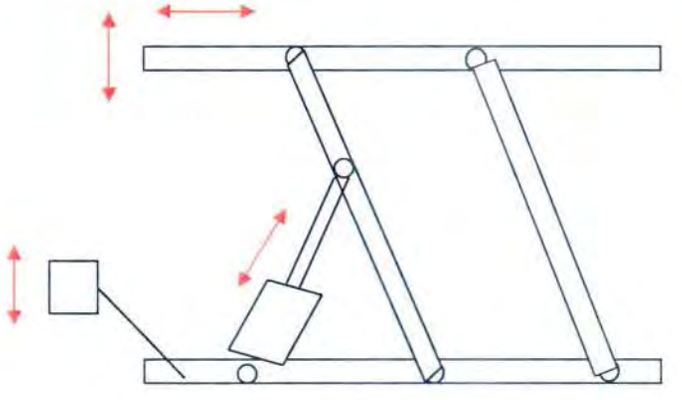
18. Πνευματική μπουκάλα, με ηλεκτρικό μοτέρ και μονοκόμματα, παράλληλα στηρίγματα



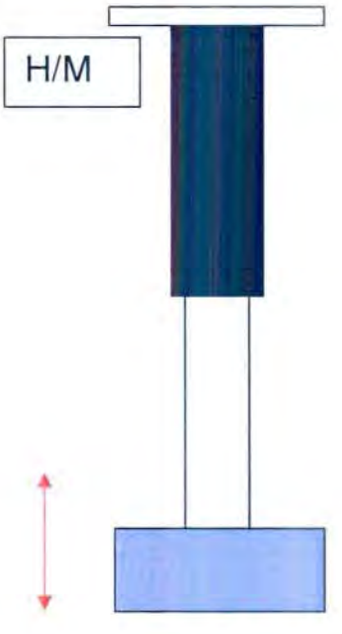
19. Υδραυλική μπουκάλα, με ηλεκτρικό μοτέρ και μονοκόμματα, παράλληλα στηρίγματα



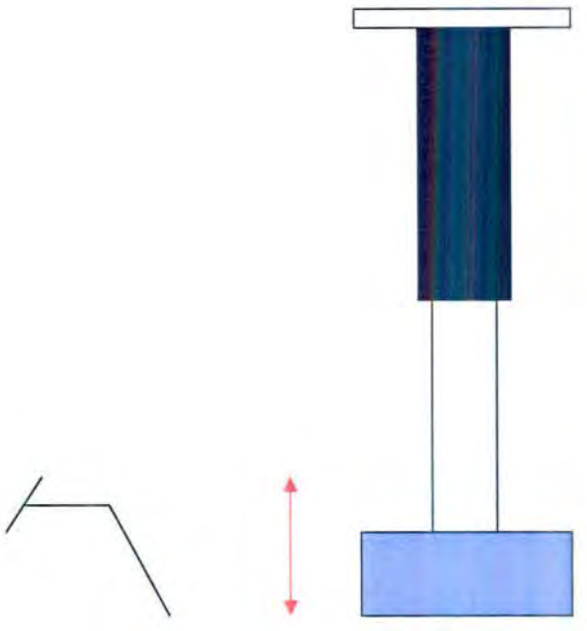
20. Υδραυλική μπουκάλα, ποδοκίνητη, με μονοκόμματα, παράλληλα στηρίγματα



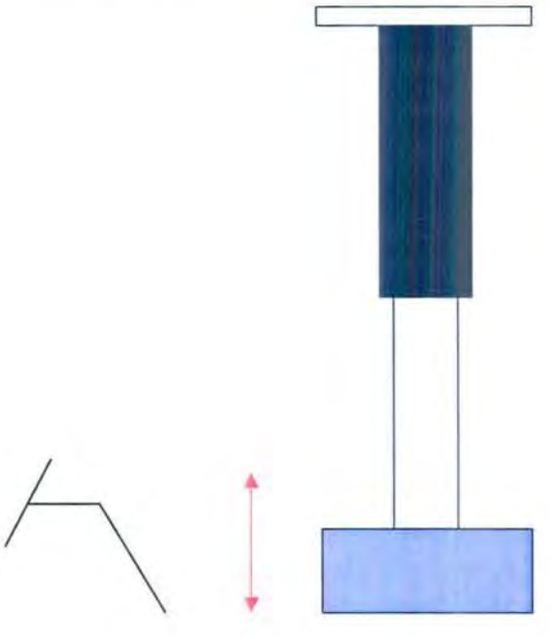
21. Ηλεκτρομαγνήτης οροφής, με πνευματική μπουκάλα και ηλεκτρικό μοτέρ



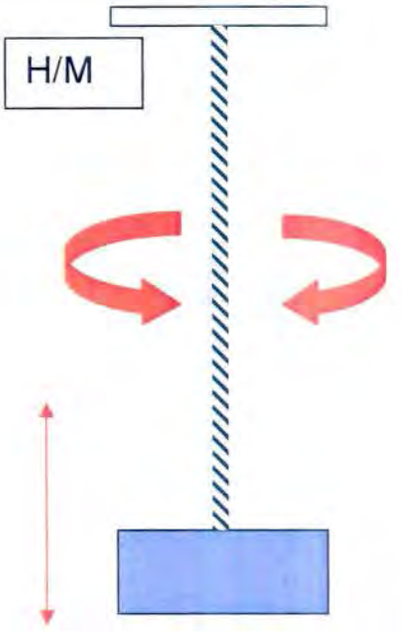
22. Ηλεκτρομαγνήτης οροφής, με ποδοκίνητη πνευματική μπουκάλα



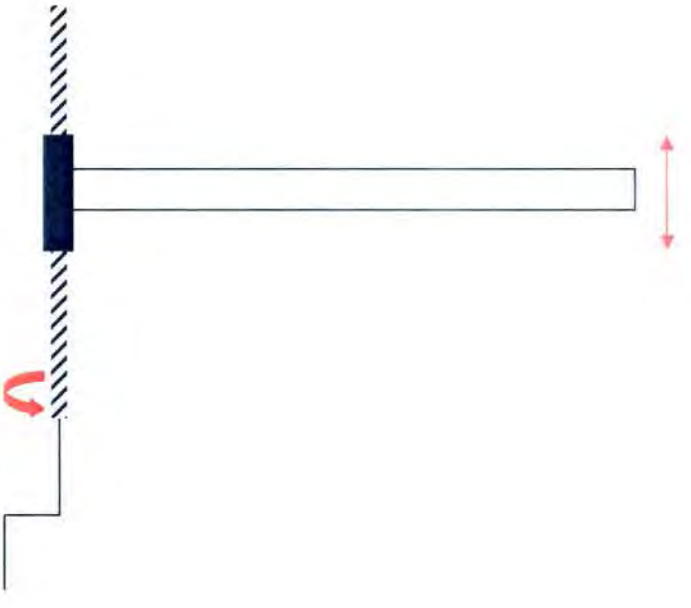
23. Ηλεκτρομαγνήτης οροφής, με ποδοκίνητη υδραυλική μπουκάλα



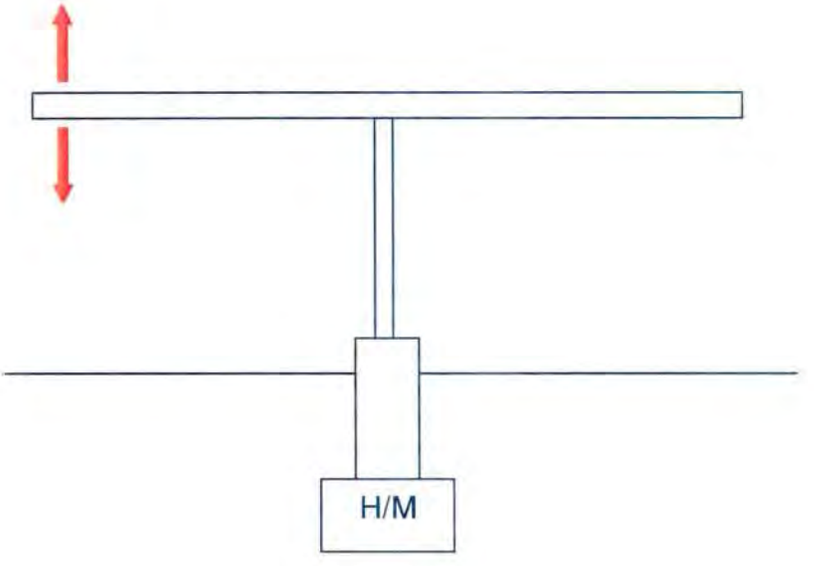
24. Ηλεκτρομαγνήτης οροφής, με κοχλιωτό άξονα, ηλεκτρικά περιστρεφόμενο



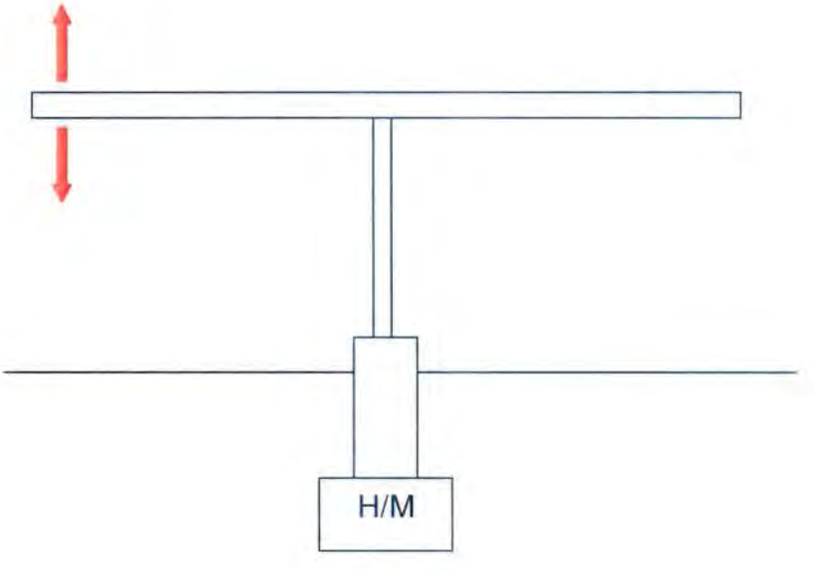
25. Κοχλιωτός άξονας, χειροστρεφόμενος, με μονόπλευρη στήριξη απ' ευθείας στο τραπέζι εργασίας



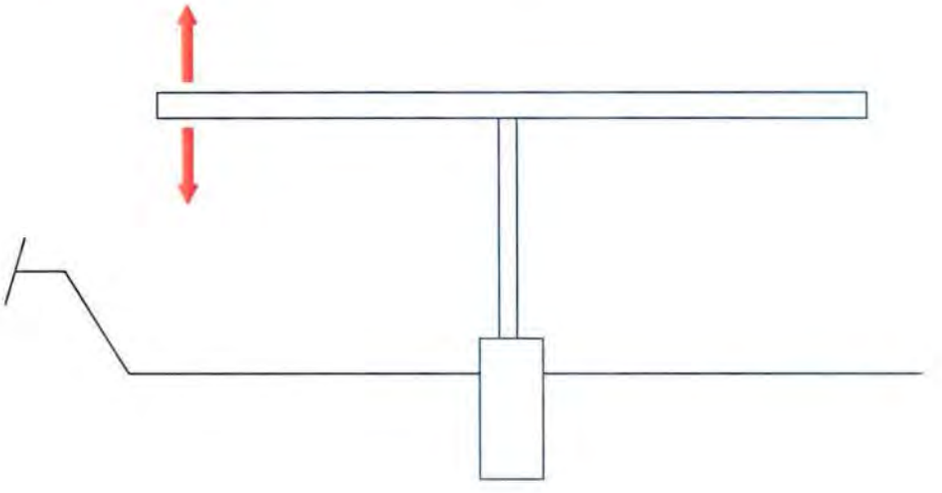
26. Κατακόρυφη πνευματική μπουκάλα, με ηλεκτρικό μοτέρ και στήριξη απ' ευθείας στο τραπέζι εργασίας



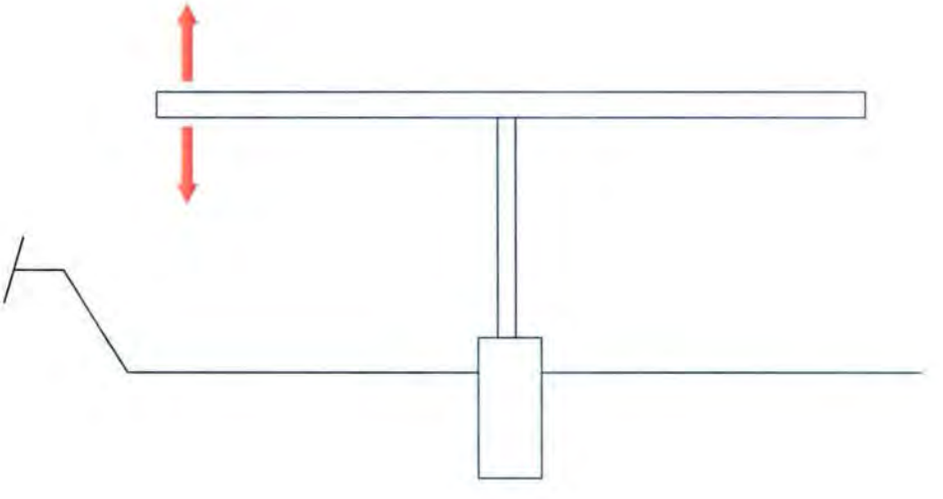
27. Κατακόρυφη υδραυλική μπουκάλα, με ηλεκτρικό μοτέρ και στήριξη απ' ευθείας στο τραπέζι εργασίας



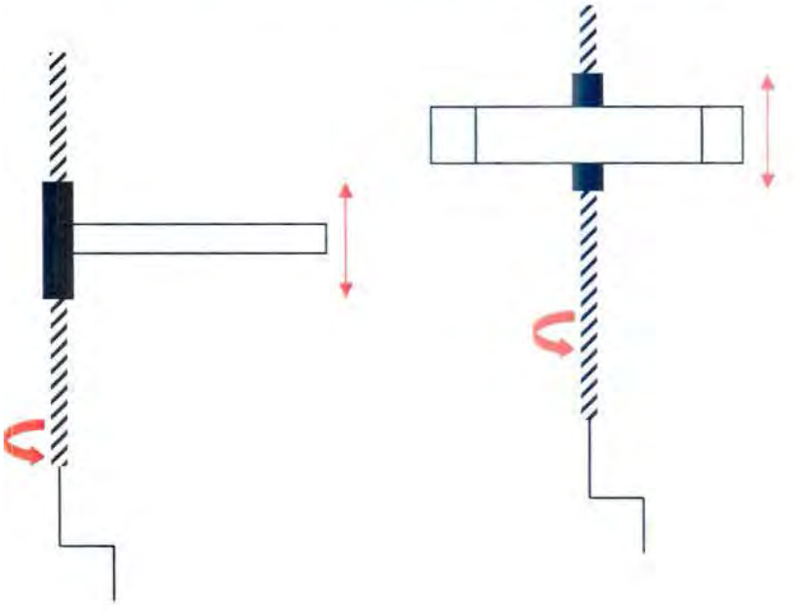
28. Κατακόρυφη πνευματική μπουκάλα, ποδοκίνητη, με στήριξη απ' ευθείας στο τραπέζι εργασίας



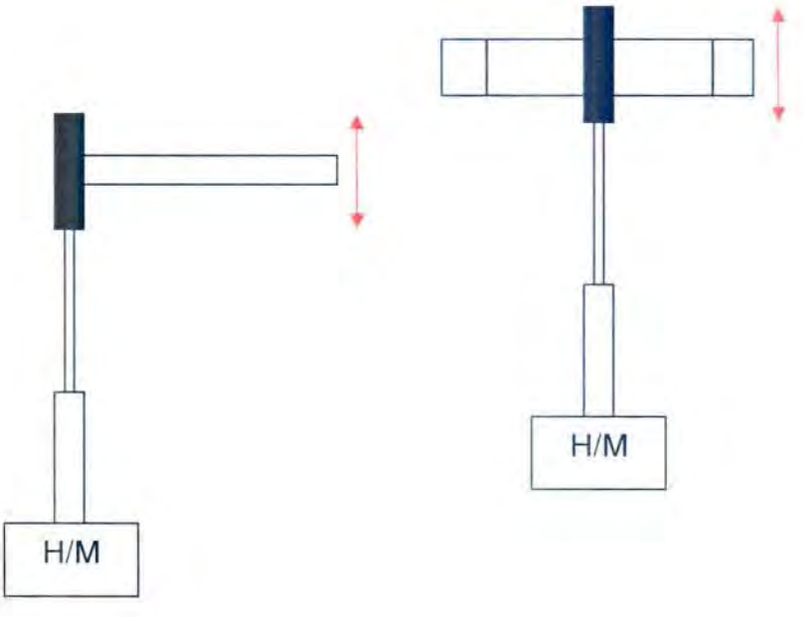
29. Κατακόρυφη υδραυλική μπουκάλα, ποδοκίνητη, με στήριξη απ' ευθείας στο τραπέζι εργασίας



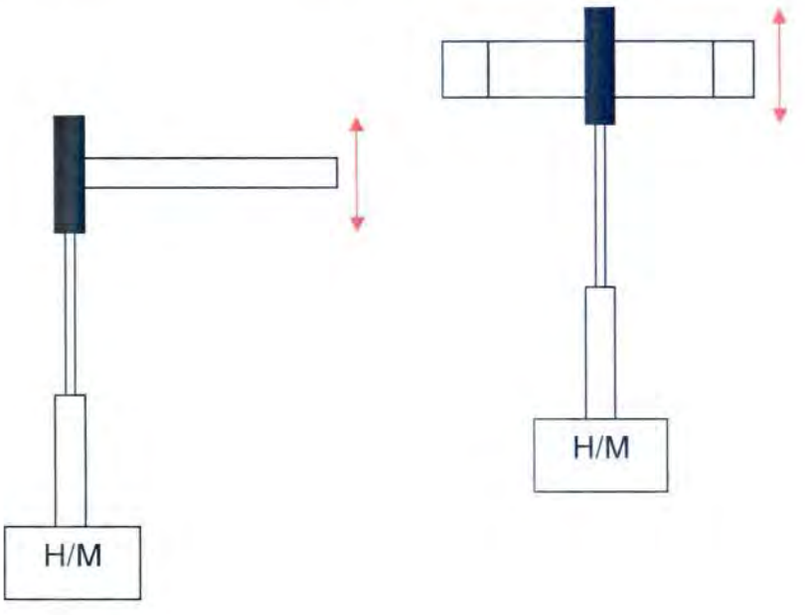
30. Μοχλοί στήριξης μοτοσικλέτας με κοχλιωτό άξονα, χειροστρεφόμενο



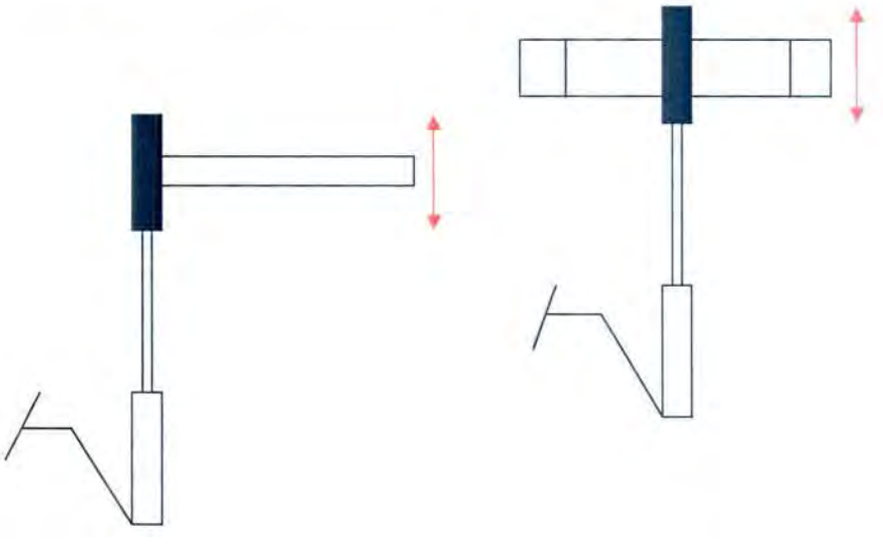
31. Κατακόρυφη πνευματική μπουκάλα, με ηλεκτρικό μοτέρ και μοχλούς στήριξης μοτοσικλέτας



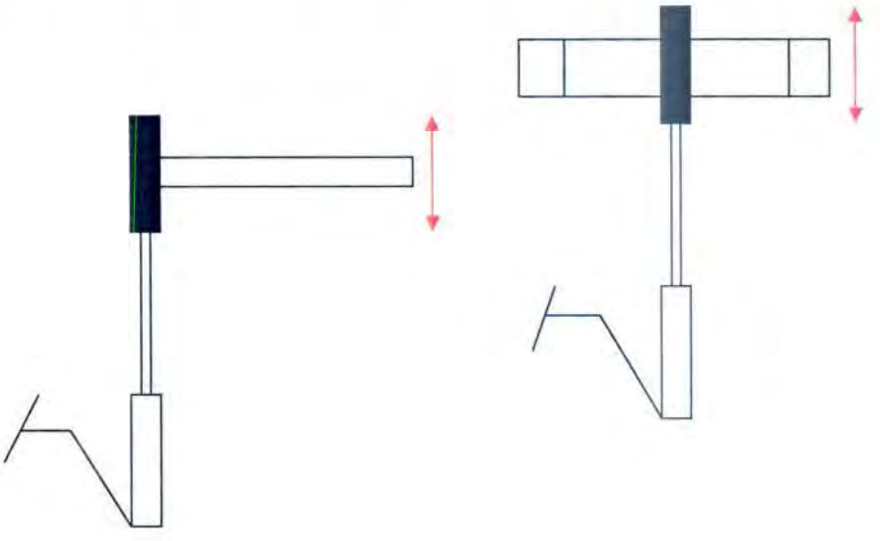
32. Κατακόρυφη υδραυλική μπουκάλα, με ηλεκτρικό μοτέρ και μοχλούς στήριξης μοτοσικλέτας



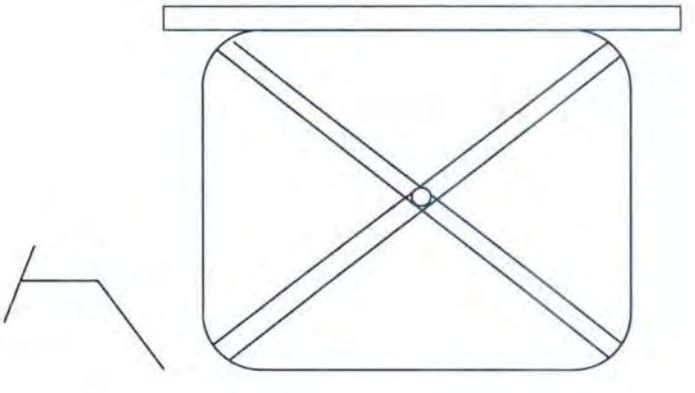
33. Κατακόρυφη πνευματική μπουκάλα, ποδοκίνητη, με μοχλούς στήριξης μοτοσικλέτας



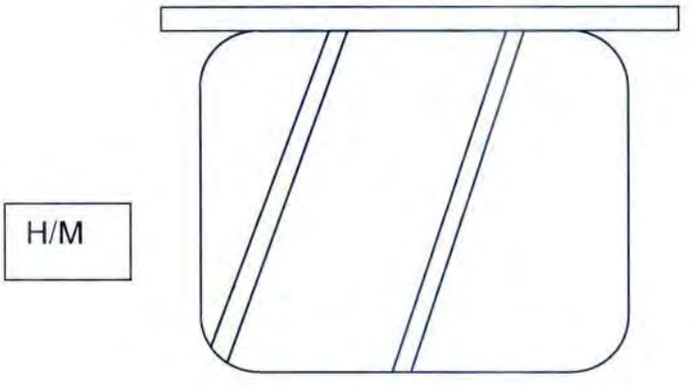
34. Κατακόρυφη υδραυλική μπουκάλα, ποδοκίνητη, με μοχλούς στήριξης μοτοσικλέτας



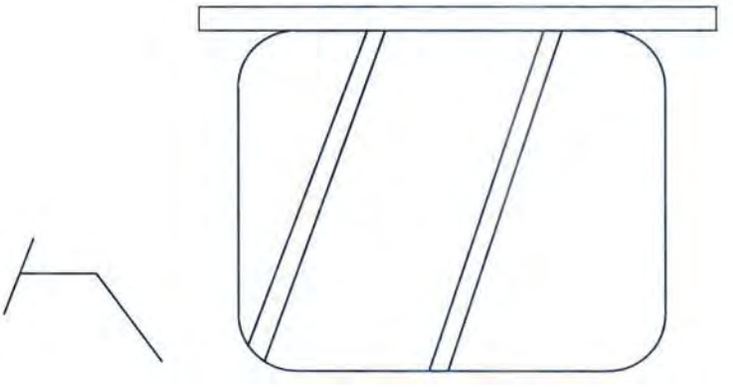
35. Αερόσακος, με ποδοκίνητη πνευματική αντλία και μονοκόμματα διασταυρούμενα στηρίγματα



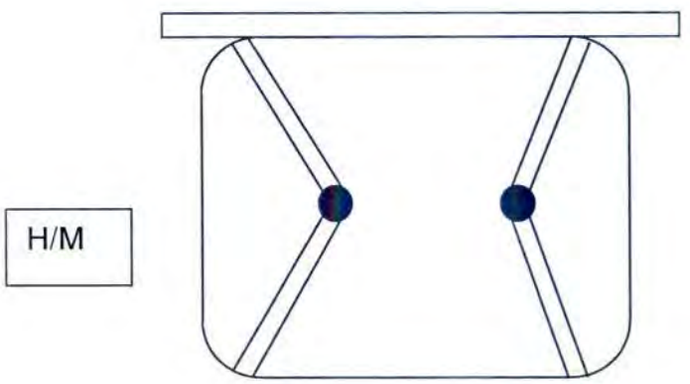
36. Αερόσακος, με ηλεκτροκίνητη πνευματική αντλία και μονοκόμματα παράλληλα στηρίγματα



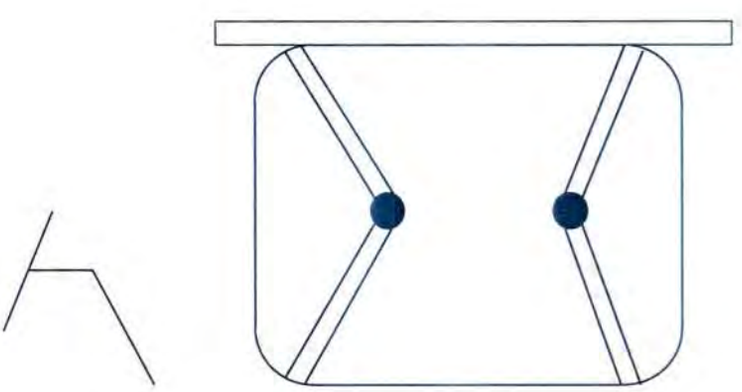
37. Αερόσακος, με ποδοκίνητη πνευματική αντλία και μονοκόμματα παράλληλα στηρίγματα



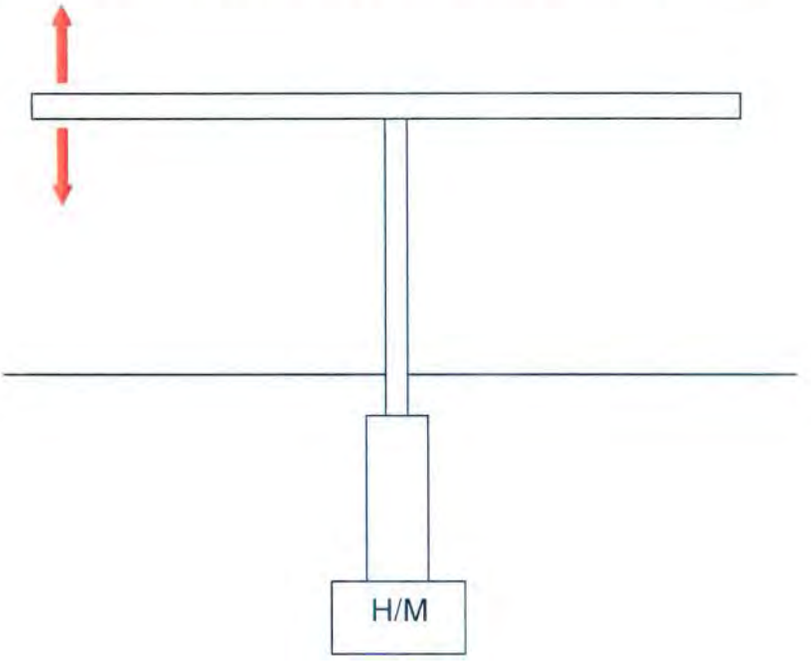
38. Αερόσακος, με ηλεκτροκίνητη πνευματική αντλία και αρθρωτά στηρίγματα



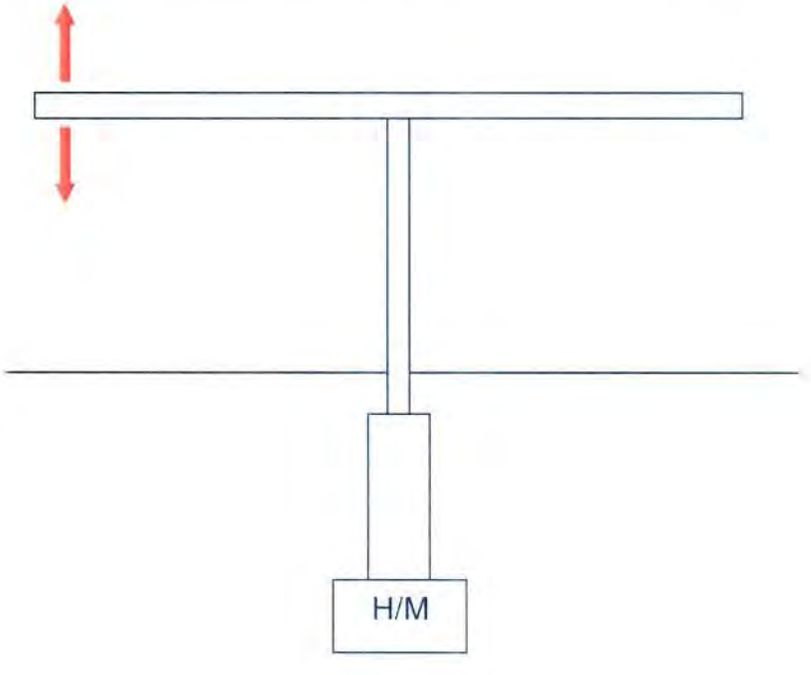
39. Αερόσακος, με ποδοκίνητη πνευματική αντλία και αρθρωτά στηρίγματα



40. Τραπέζι εργασίας, απ' ευθείας στηριζόμενο σε πνευματική μπουκάλα, βυθιζόμενο στο έδαφος



41. Τραπέζι εργασίας, απ' ευθείας στηριζόμενο σε υδραυλική μπουκάλα, βυθιζόμενο στο έδαφος



1.5 Πίνακας επιλογής

	ΠΙΝΑΚΑΣ ΕΠΙΛΟΓΗΣ για το ανυψωτικό μηχάνημα μοτοσικλετών	Σελίδα 1

Καταγραφή της παραλλαγής λύσης (L_v)	Κρίση των παραλλαγών λύσεων (L_v) σύμφωνα με **ΚΡΙΤΗΡΙΑ ΕΠΙΛΟΓΗΣ**: (+) ναι (-) όχι (;) έλλειψη πληροφόρησης (!) Επανέλεγχος του πίνακα προδιαγραφών	**ΑΠΟΦΑΣΗ** Χαρακτηρισμός των παραλλαγών λύσεων (L_v): (+) λύση άξια για εξέλιξη (-) απόρριψη λύσης (;) συγκέντρωση πληροφοριών (νέα κρίση της λύσης) (!) έλεγχος του πίνακα προδιαγραφών για αλλαγές

L_v	Λύσης συμβιβαστή με τη θέση του προβλήματος	Πληροί τους όρους του πίνακα προδιαγραφών	Υπάρχουν κατ' αρχήν πιθανότητες πραγματοποίησης	Αναμένεται επιτρεπτό κόστος	Υπάρχει άμεση ασφάλεια στην κατασκευή	Προτιμάται στην περιοχή κατασκευών μας	**Παρατηρήσεις** (υποδείξεις, αιτιολογίες)	Απόφαση
	A	B	C	D	E	F		
1	+	+	+	+	+	+		
2	+	+	+	+	+	+		
3	+	-					B: Προδιαγραφές	
4	+	+	+	-			D: Επεξεργασία - ποσότητα α' ύλης	
5	+	-					B: Προδιαγραφές	
6	+	+	+	+	-		E: Άμεση εμπλοκή χρήστη	
7	+	+	+	-			D: Επεξεργασία - ποσότητα α' ύλης	
8	+	+	-				C: Στήριξη - στεγάνωση	
9	+	+	+	-			D: Επεξεργασία - ποσότητα α' ύλης	
10	+	+	+	-			D: Χρήση 2 μπουκαλών + ΗΜ	
11	+	+	+	-			D: Χρήση 2 μπουκαλών + ΗΜ	
12	+	+	+	+	-		E: Άμεση εμπλοκή χρήστη	
13	+	+	+	+	-		E: Άμεση εμπλοκή χρήστη	
14	+	+	+	+	-		E: Άμεση εμπλοκή χρήστη	
15	+	+	+	+	+	-	F: Προτιμάται υδραυλικό λόγω μεγάλης δύναμης	
16	+	+	+	+	-		E: Άμεση εμπλοκή χρήστη	
17	+	+	+	+	-		E: Άμεση εμπλοκή χρήστη	
18	+	+	+	+	+	-	F: Προτιμάται υδραυλικό λόγω μεγάλης δύναμης	
19	+	+	+	+	+	+		
20	+	+	+	+	-		E: Άμεση εμπλοκή χρήστη	

	ΠΙΝΑΚΑΣ ΕΠΙΛΟΓΗΣ για το ανυψωτικό μηχάνημα μοτοσικλετών	Σελίδα 2

Καταγραφή της παραλλαγής λύσης (L_v)	Κρίση των παραλλαγών λύσεων (L_v) σύμφωνα με **ΚΡΙΤΗΡΙΑ ΕΠΙΛΟΓΗΣ**: (+) ναι (-) όχι (;) έλλειψη πληροφόρησης (!) Επανέλεγχος του πίνακα προδιαγραφών	**ΑΠΟΦΑΣΗ** Χαρακτηρισμός των παραλλαγών λύσεων (L_v): (+) λύση άξια για εξέλιξη (-) απόρριψη λύσης (;) συγκέντρωση πληροφοριών (νέα κρίση της λύσης) (!) έλεγχος του πίνακα προδιαγραφών για αλλαγές

L_v	Λύσης συμβιβαστή με τη θέση του προβλήματος	Πληρεί τους όρους του πίνακα προδιαγραφών	Υπάρχουν κατ' αρχήν πιθανότητες πραγματοποίησης	Αναμένεται επιτρεπτό κόστος	Υπάρχει άμεση ασφάλεια στην κατασκευή	Προτιμάται στην περιοχή κατασκευών μας	**Παρατηρήσεις** (υποδείξεις, αιτιολογίες)	Απόφαση
	A	B	C	D	E	F		
21	+	-					B: Προδιαγραφές	
22	+	-					B: Προδιαγραφές	
23	+	-					B: Προδιαγραφές	
24	+	-					B: Προδιαγραφές	
25	+	+	+	+	-		E: Άμεση εμπλοκή χρήστη	
26	+	+	+	-			D: Επεξεργασία - ποσότητα α' ύλης	
27	+	+	+	-			D: Επεξεργασία - ποσότητα α' ύλης	
28	+	+	+	-			D: Επεξεργασία - ποσότητα α' ύλης	
29	+	+	+	-			D: Επεξεργασία - ποσότητα α' ύλης	
30	+	+	+	-			D: Επεξεργασία - ποσότητα α' ύλης	
31	+	+	+	-			D: Επεξεργασία - ποσότητα α' ύλης	
32	+	+	+	-			D: Επεξεργασία - ποσότητα α' ύλης	
33	+	+	+	-			D: Επεξεργασία - ποσότητα α' ύλης	
34	+	+	+	-			D: Επεξεργασία - ποσότητα α' ύλης	
35	+	+	-				C: Στήριξη - στεγάνωση	
36	+	+	-				C: Στήριξη - στεγάνωση	
37	+	+	-				C: Στήριξη - στεγάνωση	
38	+	+	-				C: Στήριξη - στεγάνωση	
39	+	+	-				C: Στήριξη - στεγάνωση	
40	+	+	+	-			D: Επεξεργασία - ποσότητα α' ύλης	
41	+	+	+	-			D: Επεξεργασία - ποσότητα α' ύλης	

1.6 Λύσεις για τις επιμέρους λειτουργίες και συνδυασμός τους σε τελικές ολικές λύσεις (πίνακας Zwicky)

ΠΙΝΑΚΑΣ ZWICKY

ΛΥΣΕΙΣ / ΛΕΙΤΟΥΡΓΙΕΣ		1	2	19
A	ΤΟΠΟΘΕΤΗΣΗ - ΑΠΟΜΑΚΡΥΝΣΗ ΜΟΤΟΣΙΚΛΕΤΑΣ	Χειροκίνητα μέσω κεκλιμένης ράμπας	Γερανός	Ταινιόδρομος
B	ΣΤΗΡΙΞΗ ΜΟΤΟΣΙΚΛΕΤΑΣ	Ενσωματωμένος μηχανισμός στο τραπέζι εργασίας	Κινητά στηρίγματα ψαλιδιού - τηρουνιού	Γρύλλος - τρίποδα
C	ΑΣΦΑΛΙΣΗ ΜΟΤΟΣΙΚΛΕΤΑΣ	Με ιμάντες από ενσωματωμένα στο τραπέζι εργασίας πλαϊνά στηρίγματα	Μέγγενη μπροστινού τροχού	Συνδυασμός μέγγενης και ιμάντων, από ενσωματωμένα στο τραπέζι εργασίας, πλαϊνά στηρίγματα
D	ΑΝΕΛΚΥΣΗ - ΚΑΘΕΛΚΥΣΗ	Κοχλιωτός άξονας, με ηλεκτρικό μοτέρ και αρθρωτά στηρίγματα	Υδραυλική μπουκάλα, με ηλεκτρικό μοτέρ και μονοκόμματα διασταυρούμενα στηρίγματα	Υδραυλική μπουκάλα, με ηλεκτρικό μοτέρ και μονοκόμματα παράλληλα στηρίγματα

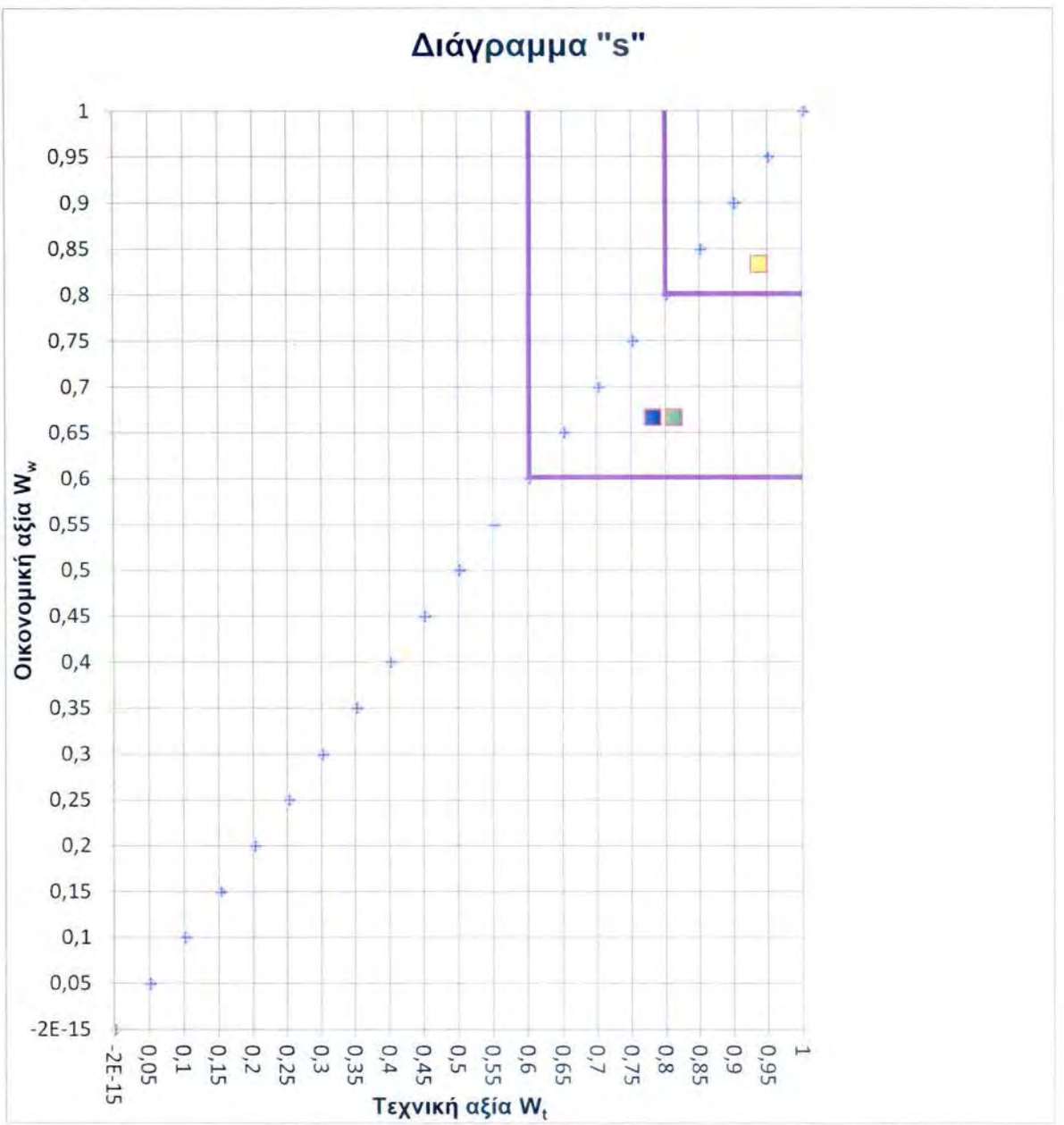
1 2 3

1.7 Πίνακες αξιολόγησης

ΠΑΡΑΛΛΑΓΗ ΤΕΧΝΙΚΑ ΚΡΙΤΗΡΙΑ	1	2	3
ΥΨΗΛΗ ΤΑΧΥΤΗΤΑ ΑΝΕΛΚΥΣΗΣ	4	4	4
ΑΞΙΟΠΙΣΤΗ ΛΕΙΤΟΥΡΓΙΑ	4	3	3
ΕΥΚΟΛΗ ΣΥΝΤΗΡΗΣΗ	4	3	3
ΒΑΡΟΣ	3	3	3
ΑΠΛΟΣ ΧΕΙΡΙΣΜΟΣ	4	4	4
ΑΣΦΑΛΕΙΑ ΧΡΗΣΗΣ	4	3	2
ΜΙΚΡΟΣ ΘΟΡΥΒΟΣ	3	3	3
ΑΝΤΟΧΗ ΣΤΗΝ ΚΟΠΩΣΗ	4	3	3
ΑΘΡΟΙΣΜΑ	30	26	25
$W_t = \sum/32$	0,94	0,81	0,78

ΠΑΡΑΛΛΑΓΗ ΤΕΧΝΙΚΑ ΚΡΙΤΗΡΙΑ	1	2	3
ΥΨΗΛΗ ΤΑΧΥΤΗΤΑ ΑΝΕΛΚΥΣΗΣ	4	4	4
ΑΞΙΟΠΙΣΤΗ ΛΕΙΤΟΥΡΓΙΑ	4	3	3
ΕΥΚΟΛΗ ΣΥΝΤΗΡΗΣΗ	4	3	3
ΒΑΡΟΣ	3	3	3
ΑΠΛΟΣ ΧΕΙΡΙΣΜΟΣ	4	4	4
ΑΣΦΑΛΕΙΑ ΧΡΗΣΗΣ	4	3	2
ΜΙΚΡΟΣ ΘΟΡΥΒΟΣ	3	3	3
ΑΝΤΟΧΗ ΣΤΗΝ ΚΟΠΩΣΗ	4	3	3
ΑΘΡΟΙΣΜΑ	30	26	25
$W_t = \sum/32$	0,94	0,81	0,78

1.8 Τεχνική και οικονομική αξία (Διάγραμμα S)



ΚΕΦΑΛΑΙΟ ΔΕΥΤΕΡΟ «ΥΠΟΛΟΓΙΣΜΟΣ ΜΕΓΕΘΩΝ»

2.1. Διαστασιολόγηση

2.1.1. Υπολογισμός σπειρώματος κοχλιωτού άξονα

Τάση εφελκυσμού ή θλίψης:

$$\sigma = \frac{F}{A_\kappa}$$

όπου:

«**σ**» η τάση εφελκυσμού ή θλίψης στον κοχλία σε N/mm^2
«**F**» η αξονική δύναμη λειτουργίας σε N
«$\mathbf{A_\kappa}$» η διατομή του πυρήνα του κοχλία σε mm^2

Τάση στρέψης:

$$\tau_t = \frac{T}{W_t} = \frac{T}{0{,}2 * d_3^3}$$

όπου:

«τ_t» η τάση στρέψης στον κοχλία σε N/mm^2
«**T**» η ροπή στρέψης που καταπονεί τον κοχλία σε Nmm
«$\mathbf{W_t}$» η (πολική ροπή αντίστασης σε στρέψη $\approx 0{,}2 * d_3^3$ σε mm^3
«$\mathbf{d_3}$» η διάμετρος του πυρήνα του κοχλία σε mm

Ροπή στρέψης:

$$T = M_G = F * r_2 * \varepsilon\varphi\left(\alpha \pm \rho'\right)$$

όπου:

«$\mathbf{M_G}$» η ροπή τριβής σε Nmm
«**F**» η αξονική δύναμη στον κοχλία σε N
«$\mathbf{r_2 = d_2/2}$» η ακτίνα κατατομής από πίνακα
«**α**» η γωνία σπειρώματος (για τραπεζοειδή σπειρώματα με μία αρχή $\alpha \approx 3^\circ \ldots 5{,}5^\circ$)
«**ρ'**» η γωνία τριβής του σπειρώματος (για τραπεζοειδή χαλύβδινο κοχλία με ορειχάλκινο περικόχλιο $\rho' \approx 12^\circ$)

Μέγιστη επιτρεπόμενη ισοδύναμη τάση για επαναλαμβανόμενη καταπόνηση:

$$\sigma_{\nu\varepsilon\pi} = 0{,}2 * R_m$$

όπου:

«$\boldsymbol{\sigma_{\nu\varepsilon\pi}}$» η ισοδύναμη επιτρεπόμενη τάση σε N/mm^2
«$\mathbf{R_m}$» η αντοχή σε εφελκυσμό

Η κατασκευή μας θα γίνει από χάλυβα St50, οπότε η αντοχή σε εφελκυσμό θα είναι:

$$R_m = 500\,{}^{N}/_{mm^2}$$

Επομένως η μέγιστη επιτρεπόμενη τάση για επαναλαμβανόμενη καταπόνηση θα είναι:

$$\sigma_{\nu\varepsilon\pi} = 0{,}2 * R_m = 0{,}2 * 500\,{}^{N}/_{mm^2} = 100\,{}^{N}/_{mm^2}$$

Έστω ότι κατασκευάζουμε τον κοχλιωτό άξονα με τραπεζοειδές σπείρωμα d = 16 mm, θα έχουμε:

$$\sigma = \frac{F}{A_\kappa} = \frac{10000}{\frac{\pi * {d_3}^2}{4}} = \frac{10000}{103{,}82} = 96{,}32\,{}^{N}/_{mm^2}$$

και

$$\tau_t = \frac{T}{W_t} = \frac{F * r_2 * \varepsilon\varphi(\alpha + \rho')}{0{,}2 * d_3^3} = \frac{10000 * 7 * \varepsilon\varphi(21^0)}{0{,}2 * 11{,}5^3}$$

$$= \frac{10000 * 7 * 0{,}38}{304{,}18} = \frac{26600}{304{,}18} = 87{,}45\,{}^{N}/_{mm^2}$$

$$\sigma_\nu = \sqrt{\sigma^2 + \tau_t^2} = \sqrt{9277{,}54 + 7647{,}50} = 130{,}1\,{}^{N}/_{mm^2}$$

Βλέπουμε ότι η ισοδύναμη τάση εφελκυσμού ή θλίψης για τραπεζοειδές σπείρωμα με ονομαστική διάμετρο d = 16 mm είναι μεγαλύτερη από τη μέγιστη επιτρεπόμενη οπότε θα κάνουμε μελέτη για άξονα με σπείρωμα μεγαλύτερης ονομαστικής διαμέτρου d = 20 mm.

$$\sigma = \frac{F}{A_\kappa} = \frac{10000}{\frac{\pi * {d_3}^2}{4}} = \frac{10000}{188{,}6} = 53{,}02\,{}^{N}/_{mm^2}$$

$$\tau_t = \frac{T}{W_t} = \frac{F * r_2 * \varepsilon\varphi(\alpha + \rho')}{0{,}2 * d_3^3} = \frac{10000 * 9 * \varepsilon\varphi(21^0)}{0{,}2 * 15{,}5^3}$$

$$= \frac{10000 * 9 * 0{,}38}{744{,}78} = \frac{34200}{744{,}78} = 45{,}92\, {}^{N}/_{mm^2}$$

$$\sigma_v = \sqrt{\sigma^2 + \tau_t^2} = \sqrt{2811{,}12 + 2108{,}64} = 70{,}14\, {}^{N}/_{mm^2}$$

$$\leq \sigma_{v\varepsilon\pi}$$

2.1.2.Υπολογισμός σε πίεση επιφανείας των ορειχάλκινων περικοχλίων του κοχλιωτού άξονα

$$p = \frac{F * P}{m * d_2 * \pi * H_1}$$

όπου:

«**p**» η πίεση επιφανείας στο σπείρωμα N/mm^2
«**F**» η αξονική δύναμη λειτουργίας σε N
«**P**» το βήμα του κοχλία σε mm/r
«**m**» φέρον ύψος του περικοχλίου σε mm (35 mm από τη διάμετρο του άξονα)
«**d_2**» μέση διάμετρος του σπειρώματος σε mm
«**H_1**» βάθος σπειρώματος σε mm
«**$p_{\varepsilon\pi}$**» η επιτρεπόμενη πίεση επιφανείας σε N/mm^2 (≈10…20 N/mm^2)

$$p = \frac{F * P}{m * d_2 * \pi * H_1} = \frac{5000 * 4}{35 * 18 * 3{,}14 * 2} = \frac{20000}{3956{,}40}$$

$$= \frac{5{,}06N}{mm^2} \leq p_{\varepsilon\pi}$$

2.1.3.Υπολογισμός αντοχής σε κάμψη

$$\sigma_b = \frac{M}{W}$$

όπου:

«σ_b» η τάση κάμψης στο στήριγμα σε N/mm^2
«**M**» η μέγιστη ροπή κάμψης σε Nmm
«**W**» η αξονική ροπή αντίστασης σε κάμψη σε mm^3

$$M = F * \frac{\alpha}{2} + F * \frac{\alpha}{2} = F * \alpha$$

όπου:

«**F**» η εφαρμοζόμενη δύναμη σε N
«**α**» η απόσταση από το σημείο εφαρμογής της δύναμης έως το κέντρο του στηρίγματος

$$W_b = \frac{h * b^2}{6}$$

όπου:

«W_b» η αξονική ροπή αντίστασης σε κάμψη στον άξονα y του στηρίγματος σε mm^3
«**h=α**» το μήκος του στηρίγματος κατά τον άξονα y σε mm
«**b**» το μήκος του στηρίγματος κατά τον άξονα x σε mm

Για τον χάλυβα St50 ισχύουν οι δύο παρακάτω σχέσεις:

$$\sigma_{bSch} \approx 0{,}9 * \sigma_{bF} \approx 0{,}9 * 330 = 297$$

$$\sigma_{bF} = 330 N/mm^2$$

Από τις 2 παραπάνω σχέσεις συνεπάγεται:

$$\sigma_{b\varepsilon\pi} = \sigma_{bSch} \approx 0{,}9 * 330 = 297\, N/mm^2$$

Αν το μήκος του στηρίγματος κατά τον άξονα των χ είναι b = 20 mm, τότε θα έχουμε:

$$\sigma_{b\varepsilon\pi} = \frac{F * \alpha}{\frac{h * b^2}{6}} \Rightarrow h = \frac{6 * F * \alpha}{\sigma_{b\varepsilon\pi} * b^2} \Rightarrow$$

$$h = \frac{6 * 2500 * 550}{297 * 400} \Rightarrow h = 69{,}44\ mm$$

2.1.4.Υπολογισμός αντοχής σε 0λίψη

$$F_\kappa = \sigma_\kappa * A$$

όπου:

«$\mathbf{F_\kappa}$» η φόρτιση κάμψης στο στήριγμα σε N
«$\boldsymbol{\sigma_\kappa}$» η τάση λυγισμού σε N/mm^2
«**A**» η διατομή της ράβδου σε mm^2

Για τον τρόπο στήριξης των στηριγμάτων έχουμε:

$$l_\kappa = \alpha = 550\ mm$$

$$\lambda = \frac{l_\kappa}{i}$$

$$i = \sqrt{I/A} = \sqrt{\frac{\frac{h * b^3}{12}}{b * h}} = \sqrt{\frac{h * b^3}{12 * b * h}} = \sqrt{\frac{b^2}{12}} = 5{,}78\ mm$$

$$\lambda = \frac{l_\kappa}{i} = \frac{550}{5{,}78} = 95{,}16$$

$$F_\kappa = \frac{\pi^2 * E * I}{l_\kappa^2} \Rightarrow E = \frac{F_\kappa * l_\kappa^2}{\pi^2 * I} \Rightarrow E = \frac{12 * F_\kappa * l_\kappa^2}{\pi^2 * h * b^3} \Rightarrow$$

$$E = \frac{12 * 2500 * 302500}{9{,}86 * 70 * 8000} \Rightarrow E = \frac{1643{,}54N}{mm^2}$$

$$\sigma_\kappa = \frac{\pi^2 * E}{\lambda^2} = \frac{9{,}86 * 1643{,}54}{9055{,}43} = \frac{1{,}79N}{mm^2}$$

Η μέγιστη επιτρεπόμενη τάση θλίψης είναι:

$$\sigma_{Sch} = 0{,}9 * R_e = 0{,}9 * 275 = \frac{247{,}5N}{mm^2}$$

2.1.5.Υπολογισμός σε πίεση επιφανείας των οπών στήριξης

$$p = \frac{F}{d * b}$$

όπου:

«**p**» μέση πίεση επιφανείας σε N/mm^2
«**F**» η φόρτιση καταπόνισης σε N
«**d**» η διάμετρος της οπής στήριξης σε mm
«**b**» το μήκος της ράβδου κατά τον άξονα χ σε mm

$$p = \frac{2500}{35 * 20} = \frac{3{,}57N}{mm^2}$$

Από πίνακα επιτρεπόμενης τάσης επιφανείας για σκληρυμένο χάλυβα έχουμε:

$P_{\varepsilon\pi} = 100\ldots170$ N/mm^2

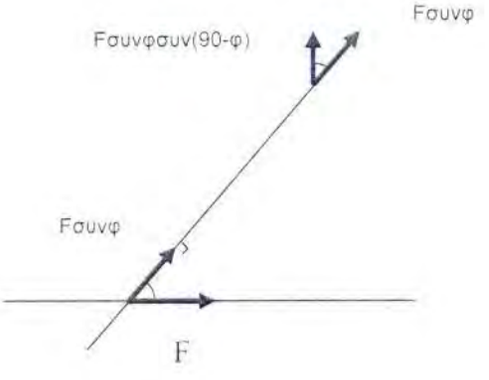
2.1.6.Υπολογισμός ισχύος ηλεκτροκινητήρα

Η ισχύς του ηλεκτροκινητήρα που θα χρησιμοποιήσουμε, θα πρέπει να είναι ικανή να παράγει ροπή μεγαλύτερη από τη ροπή σύσφιγξης M_{an}:

$$M_{an} = 0{,}2 * F * d_2$$

όπου:

«**F**» η αξονική δύναμη στον κοχλιωτό άξονα σε N
«$\mathbf{d_2}$» η μέση διάμετρος του σπειρώματος σε mm



Ο ανελκυστήρας θα έχει μέγιστο φορτίο ανύψωσης B=500 Kgr, επομένως η κάθε δοκός θα επιβαρύνεται με φορτίο B'=125 Kgr, οπότε θα πρέπει:

$$F * \sigma\upsilon\nu\varphi * \sigma\upsilon\nu(90 - \varphi) > 1250\ N$$

Η συνάρτηση:

$$\sigma\upsilon\nu\varphi * \sigma\upsilon\nu(90 - \varphi)$$

Μεταξύ των γωνιών λειτουργίας των στηριγμάτων του ανελκυστήρα, παρουσιάζει τοπικό ελάχιστο στην κατώτατη θέση όπου $\varphi=7{,}80^{0}$. Οπότε θα έχουμε:

$$F * 0{,}134 > 1250\ N \Rightarrow F > 9329\ N$$

Οπότε η απαιτούμενη ροπή σύσφιγξης θα είναι:

$$M_{an} = 0{,}2 * 9329\,N * 18\,mm = 33585\,Nmm$$

$$= 33{,}58\,Nm$$

Ο μέγιστος χρόνος ανέλκυσης από την κατώτατη στην ανώτατη θέση έχει περιοριστεί από τους πίνακες προδιαγραφών στα t=30 sec. Η απόσταση μεταξύ των αξόνων – φορέων των ορειχάλκινων περικοχλίων στην κατώτατη θέση είναι l_1= 128,227 mm, ενώ στην ανώτατη θέση είναι l_2=344,438 mm. Οπότε η απόσταση που θα πρέπει να διανύει ο κάθε άξονας επί του κοχλιωτού άξονα, από την κατώτατη στην ανώτατη θέση είναι:

$$l = \frac{l_2 - l_1}{2} = \frac{344{,}438 - 128{,}22}{2} = 108{,}1\,mm$$

Το βήμα του τραπεζοειδούς σπειρώματος στον κοχλιωτό άξονα είναι p= 4mm, οπότε οι απαιτούμενες στροφές (n) του ηλεκτροκινητήρα θα είναι:

$$n = \frac{108{,}1\,mm}{4mm * 30sec} = 0{,}9\,rps \approx 1\,rps = 60\,rpm$$

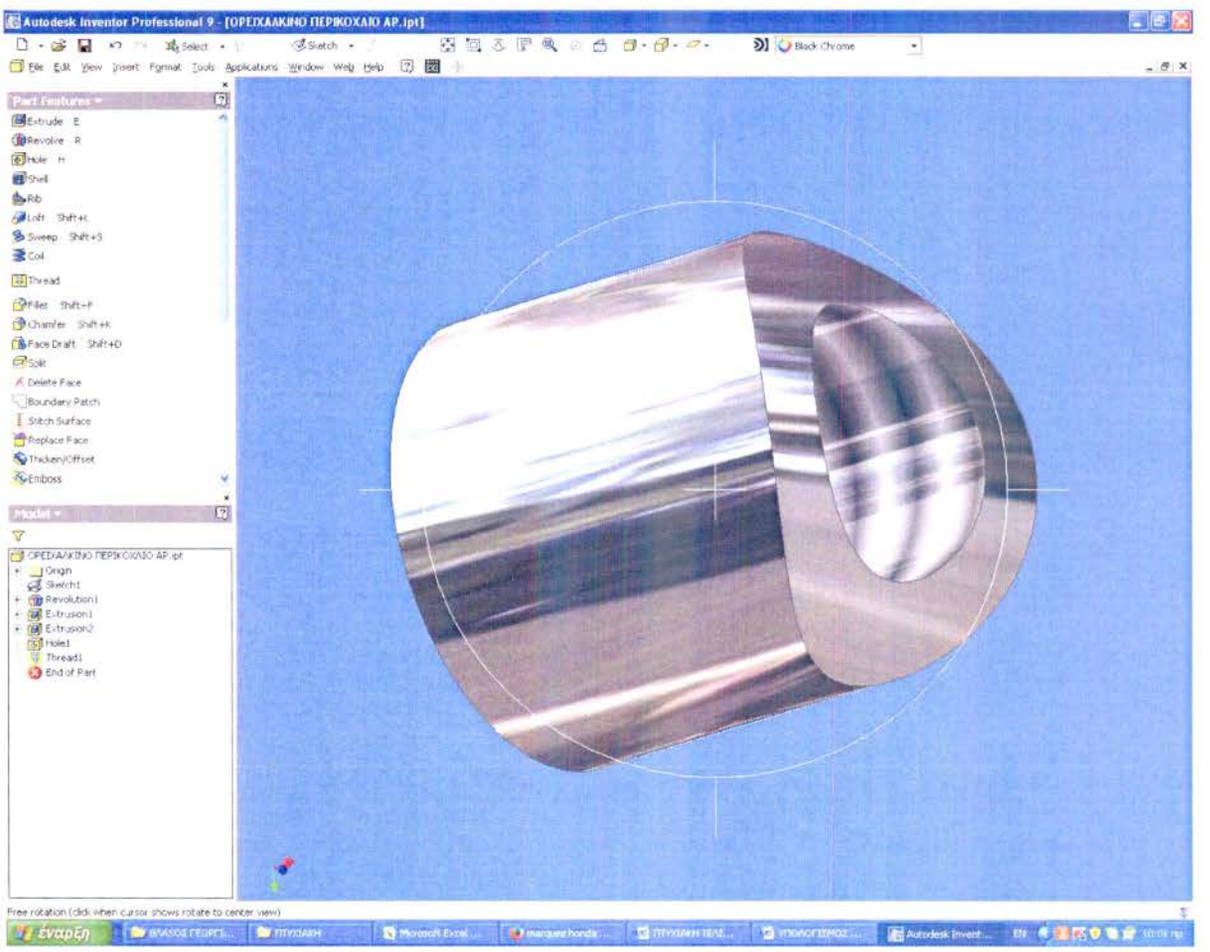
Οπότε η ισχύς τους ηλεκτροκινητήρα θα πρέπει να είναι:

$$P = \frac{M_{an} * n}{9{,}55} = \frac{33{,}58\,Nm * 60\,rpm}{9{,}55} = 211\,Watt$$
$$= 0{,}21\,kW$$

ΚΕΦΑΛΑΙΟ ΤΡΙΤΟ «ΗΛΕΚΤΡΟΝΙΚΗ ΣΧΕΔΙΑΣΗ ΚΑΤΑΣΚΕΥΗΣ»

3.1. Αναφορά στο πρόγραμμα ηλεκτρονικής σχεδίασης

Η ηλεκτρονική σχεδίαση των εξαρτημάτων και η συναρμολόγηση της κατασκευής πραγματοποιήθηκαν με το πρόγραμμα Autodesk Inventor Professional 9 και τα σχέδια παρατίθενται στο παράρτημα.

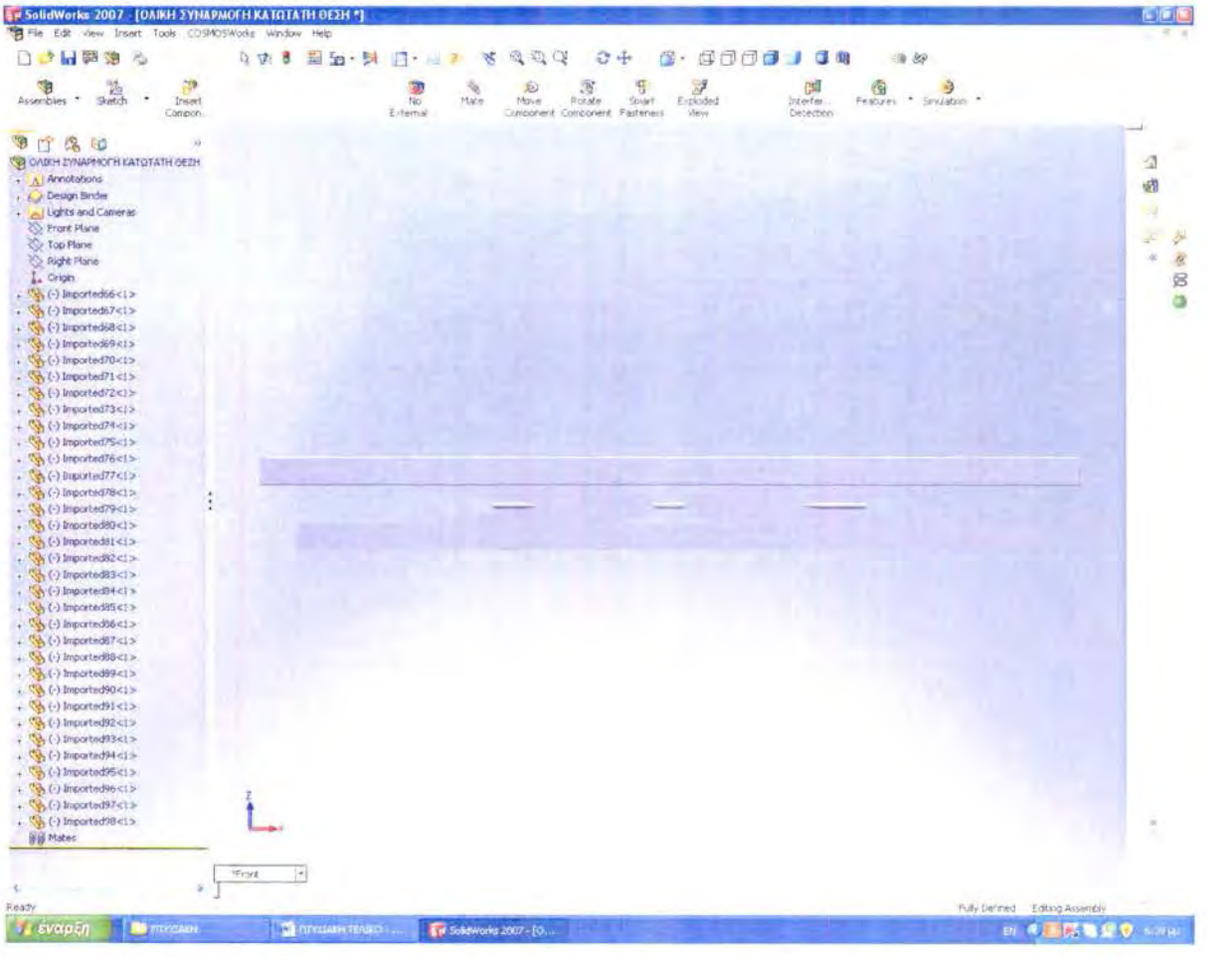


ΚΕΦΑΛΑΙΟ ΤΕΤΑΡΤΟ «ΣΤΑΤΙΚΟΣ ΕΛΕΓΧΟΣ ΚΑΤΑΣΚΕΥΗΣ»

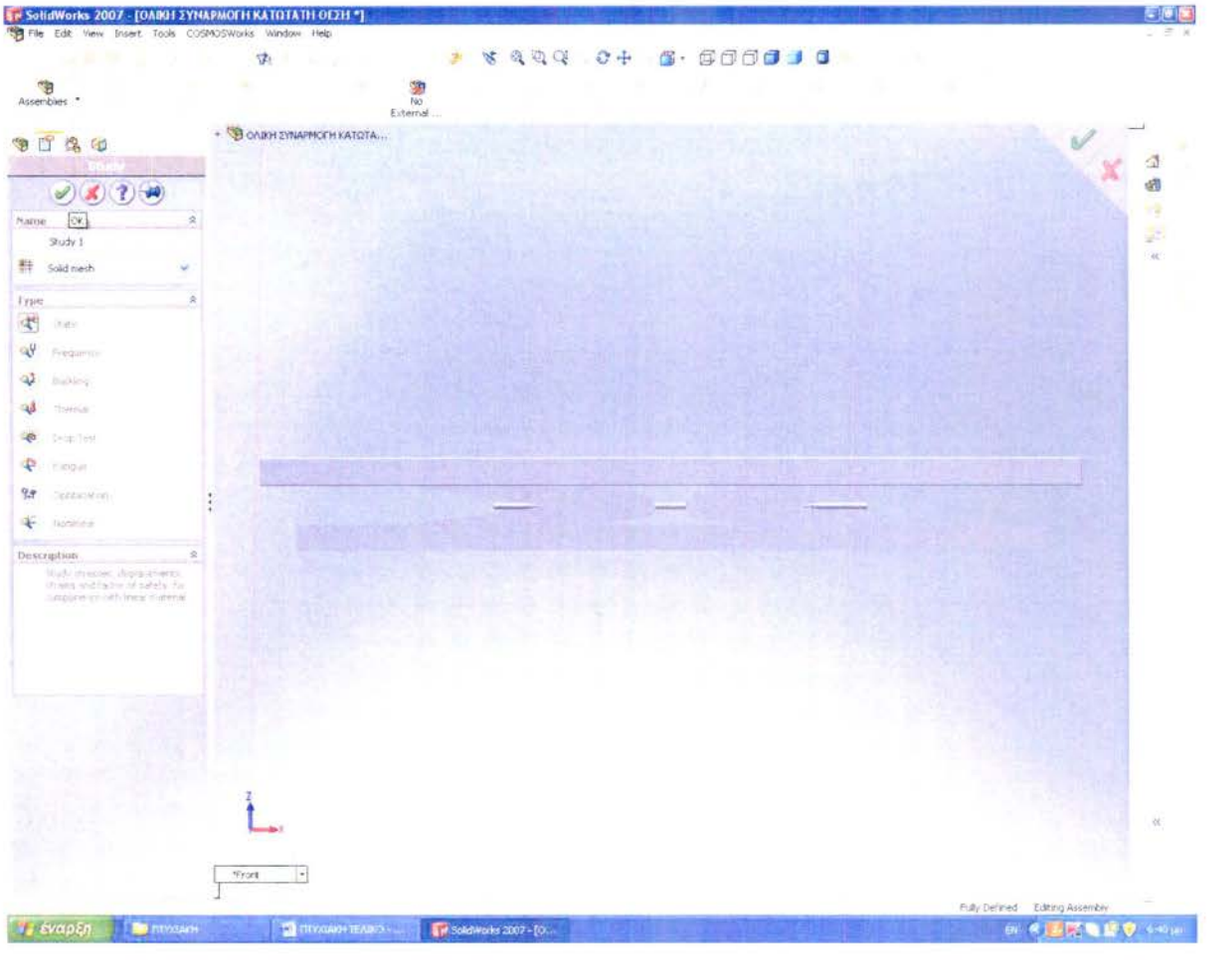
4.1. Ανάλυση διαδικασίας στατικού ελέγχου με το πρόγραμμα Solidworks

Ο στατικός έλεγχος της κατασκευής πραγματοποιήθηκε με το πρόγραμμα Solidworks 2007. Η κατασκευή ελέγχθηκε στην κατώτατη, τη μεσαία και την ανώτατη θέση λειτουργίας της. Τα βήματα της διαδικασίας περιγράφονται αναλυτικά παρακάτω, ενώ τα αναλυτικά αποτελέσματα του ελέγχου παρατίθενται στο παράρτημα.

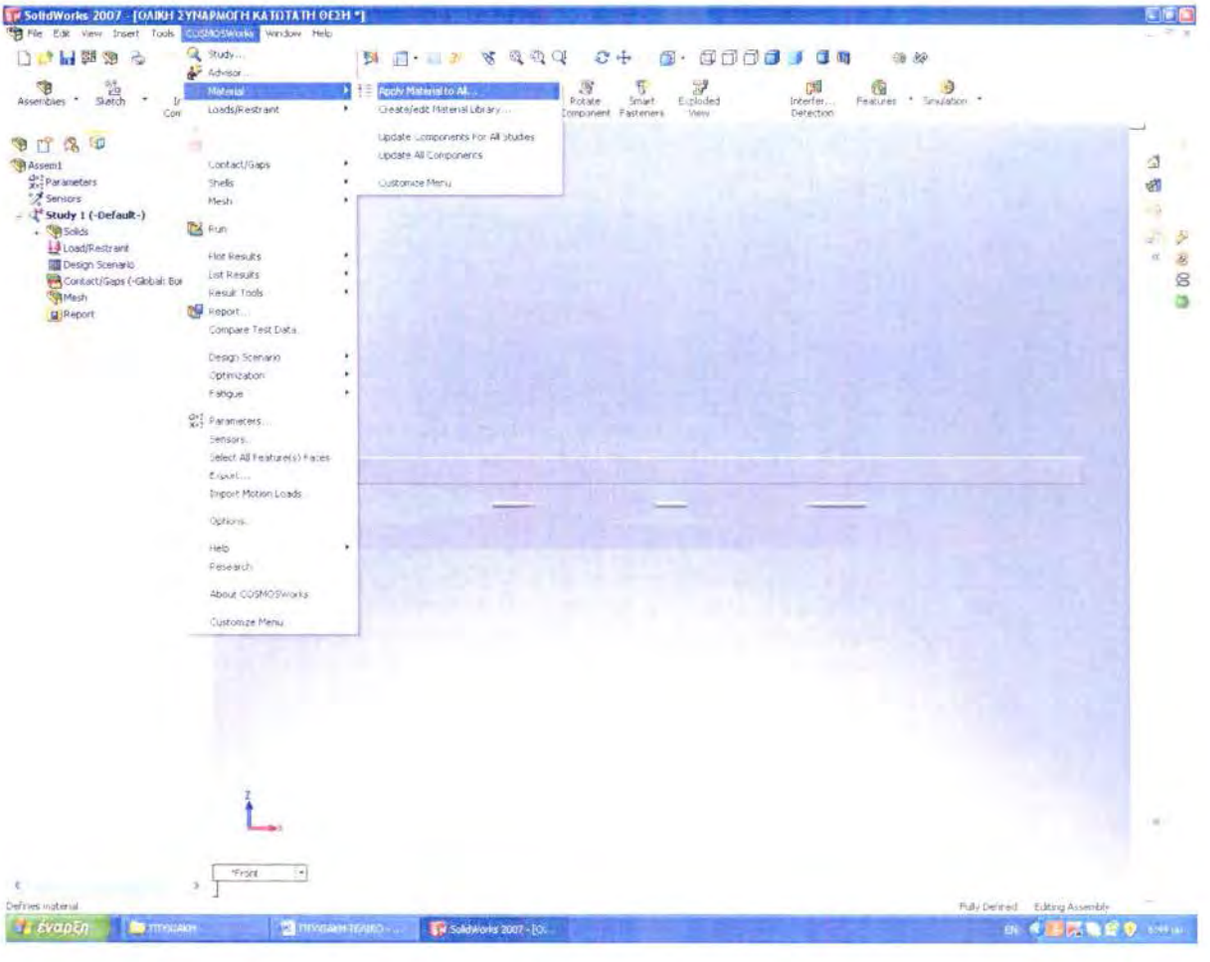
Αρχικά ανοίγουμε το αρχείο με το αντικείμενο στο οποίο θα διενεργηθεί ο στατικός έλεγχος.



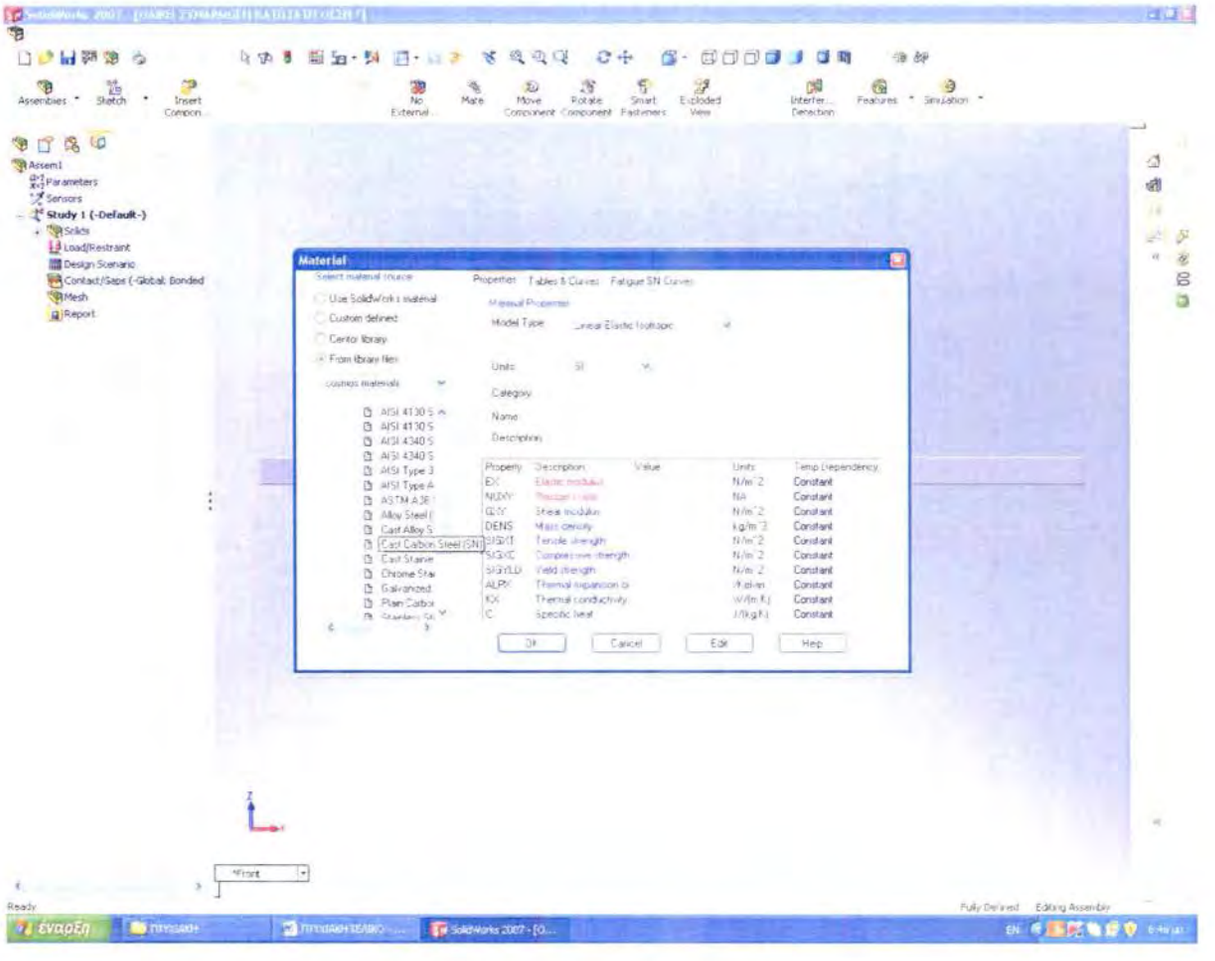
Κατόπιν από την πλατφόρμα COSMOSWorks, επιλέγουμε "Study" και στη συνέχεια από τον εμφανιζόμενο πίνακα επιλέγουμε "Static".



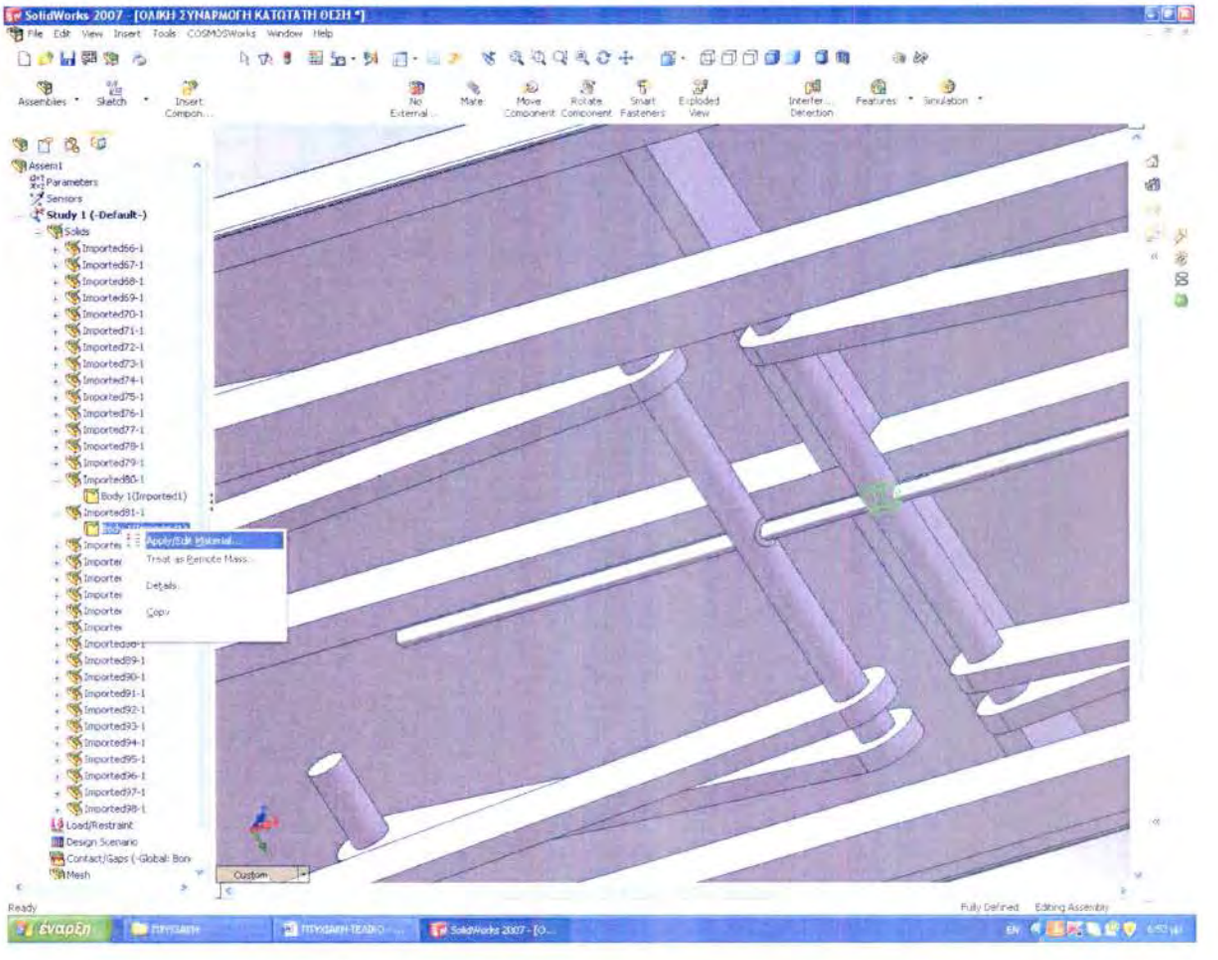
Αφού επιλέξουμε το είδος του ελέγχου, που θα διενεργήσουμε, πρέπει να καθορίσουμε το υλικό από το οποίο είναι κατασκευασμένο το προς έλεγχο αντικείμενο. Από την πλατφόρμα "COSMOSWorks" επιλέγουμε "Material" και "Apply Material to All".



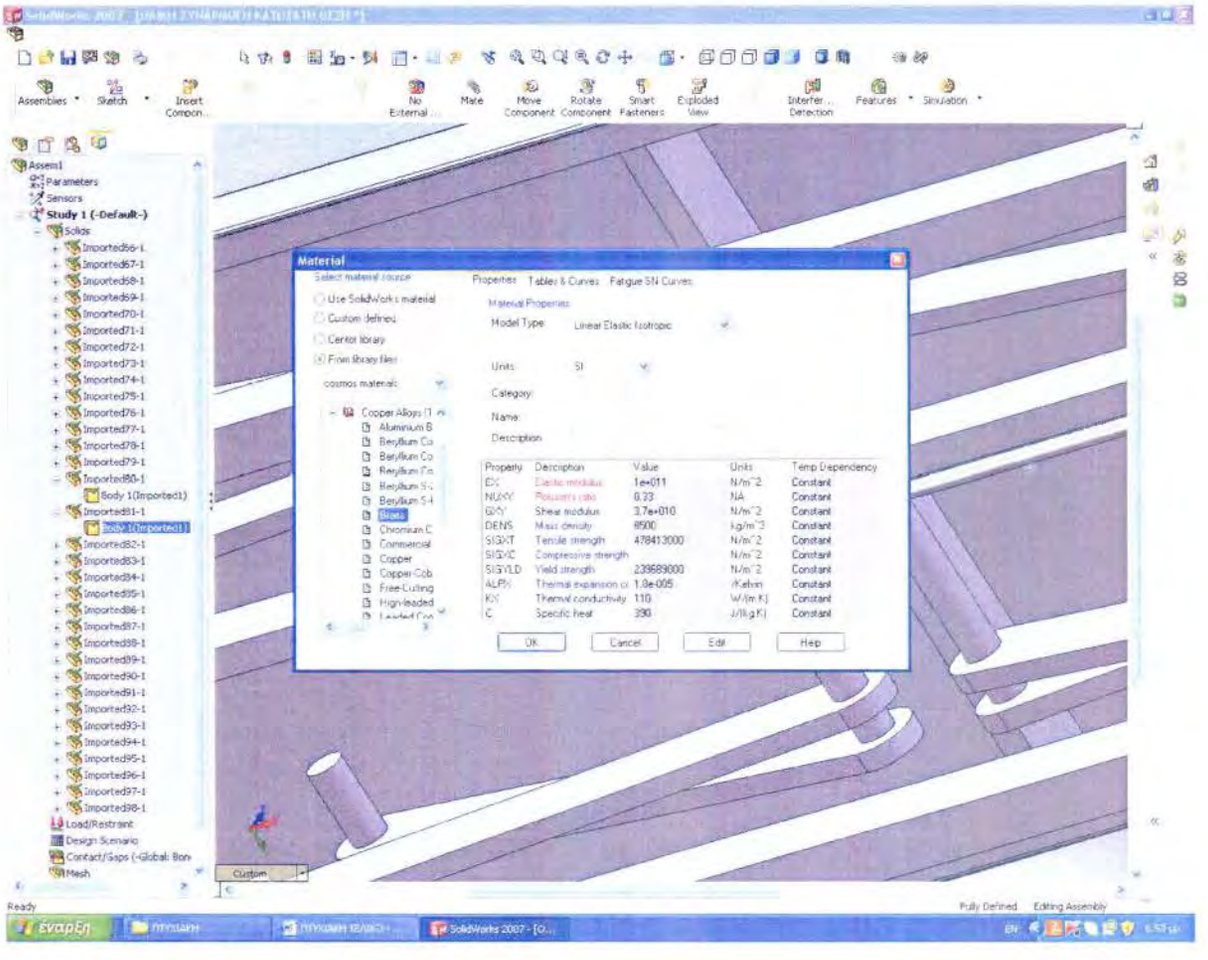
Από τον πίνακα, που εμφανίζεται, επιλέγουμε “From Library Files” και στη συγκεκριμένη περίπτωση από τον κατάλογο “Steel” επιλέγουμε “Cast Carbon Steel”.



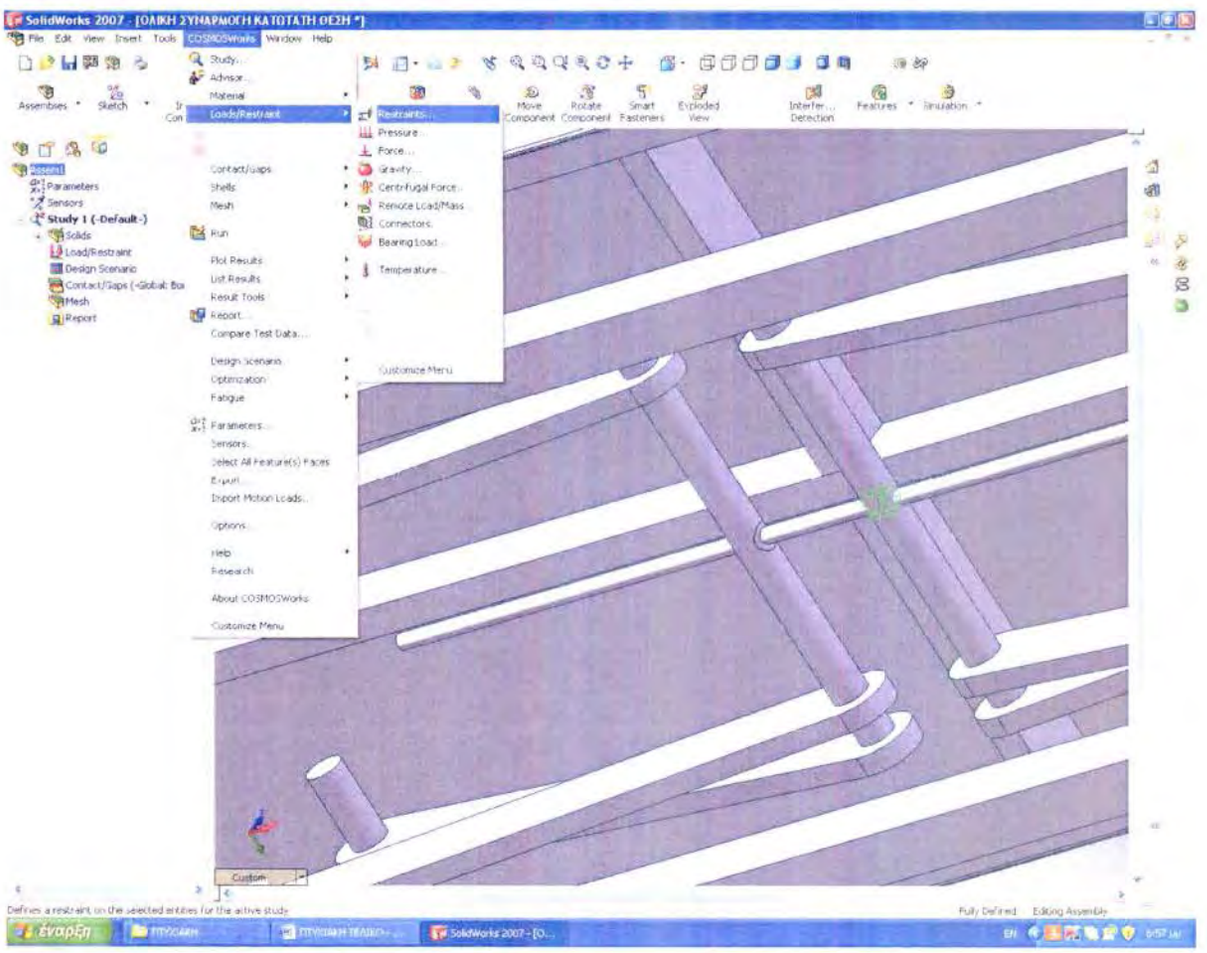
Επειδή στην κατασκευή μας υπάρχουν και ορειχάλκινα τμήματα, από τον κατάλογο με τα επιμέρους τμήματα της κατασκευής, εντοπίζουμε τα τεμάχια, στα οποία θέλουμε να αλλάξουμε το υλικό κατασκευής και επιλέγουμε "Apply/Edit Material".



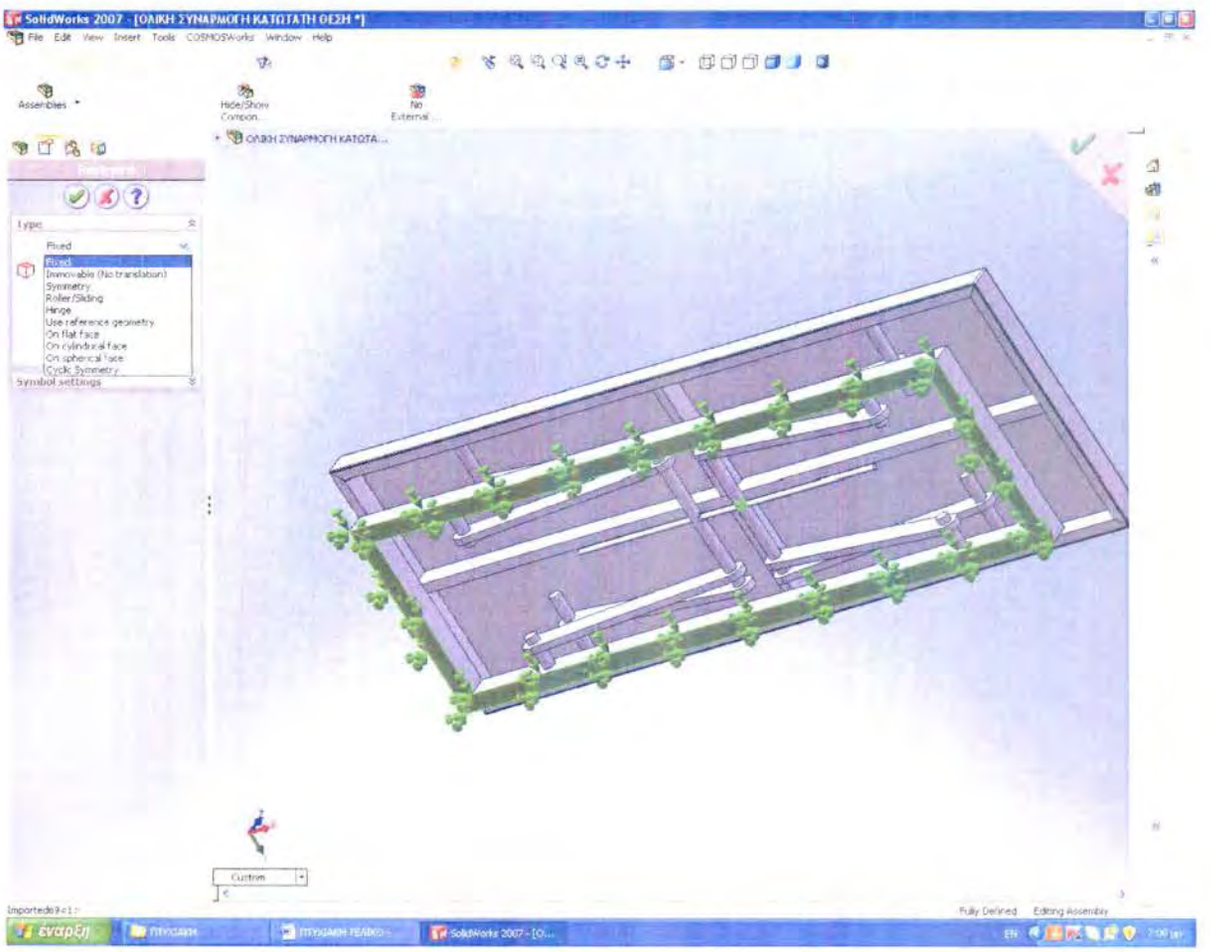
Κατόπιν όπως παραπάνω επιλέγουμε “Brass” από τον κατάλογο “Copper Alloys”.



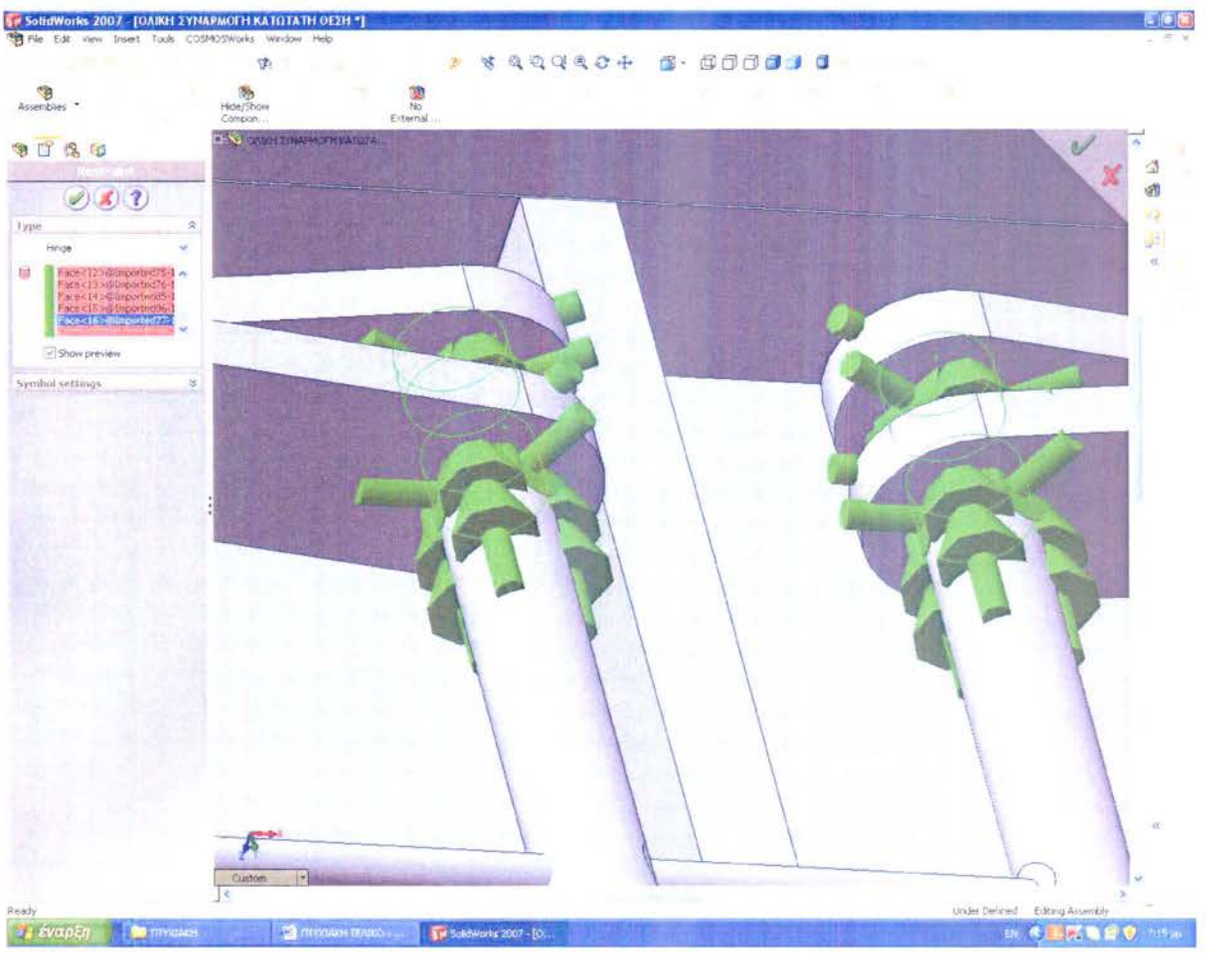
Αφού καθορίσουμε και το υλικό κατασκευής, σειρά έχουν οι συναρμογές, που εφαρμόζονται στην κατασκευή. Από την πλατφόρμα "COSMOSWorks" επιλέγουμε "Loads/Restraint" και κατόπιν "Restraints", ώστε να καθορίσουμε τις πακτώσεις, τις αρθρώσεις και τις κυλίσεις, που εφαρμόζονται στη συγκεκριμένη κατασκευή.



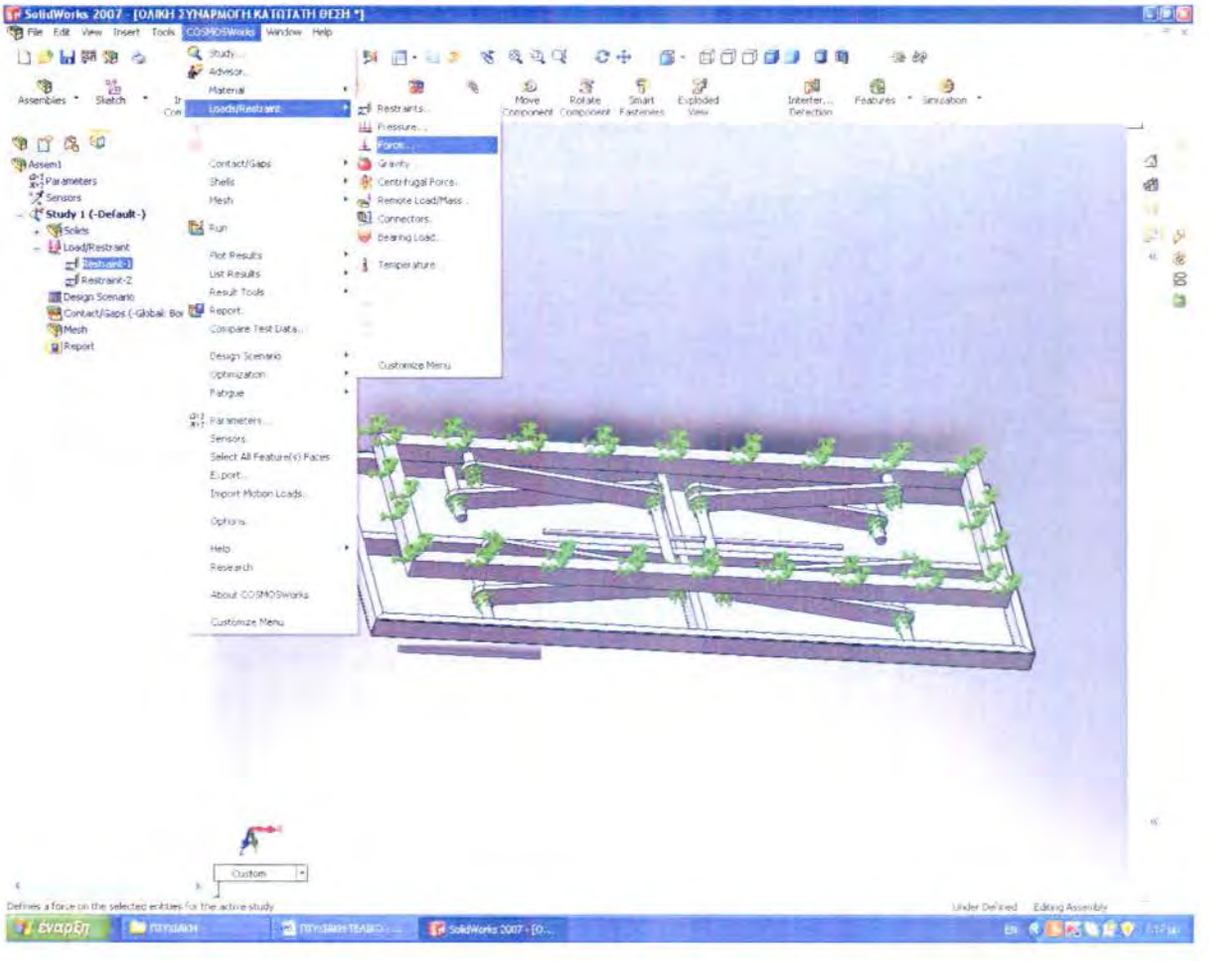
Ξεκινώντας από τις πακτώσεις, επιλέγουμε τις πακτωμένες επιφάνειες και από τον πίνακα με τα είδη των συναρμογών επιλέγουμε "Fixed".



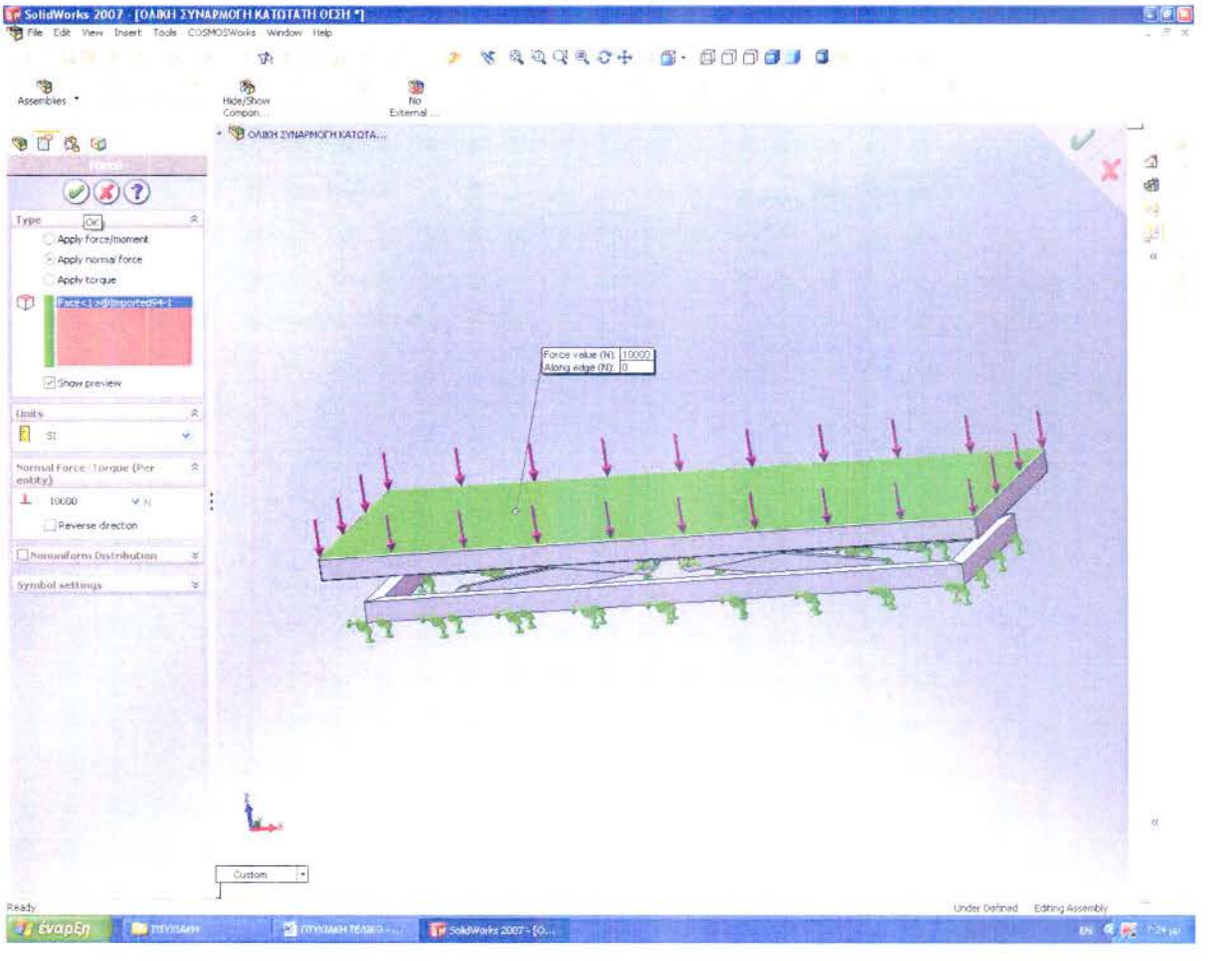
Στη συνέχεια επιλέγουμε τις αρθρωμένες επιφάνειες και από τον πίνακα με τα είδη συναρμογών επιλέγουμε "Hinge".



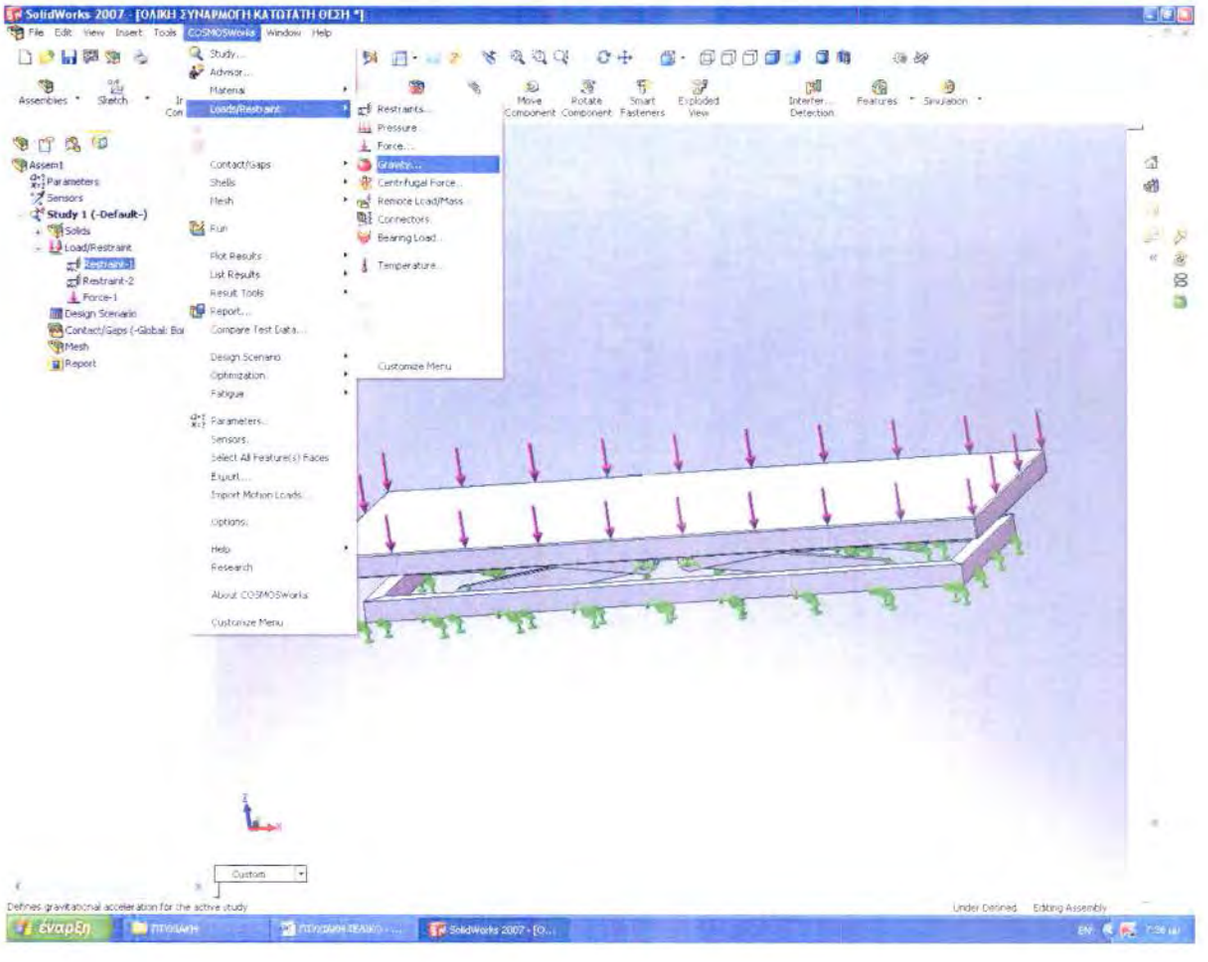
Αφού τελειώσουμε με τις συναρμογές, πρέπει να καθορίσουμε τα φορτία, με τα οποία επιφορτίζεται η κατασκευή. Από την πλατφόρμα "COSMOSWorks" επιλέγουμε και πάλι "Loads/Restraint" και στη συνέχεια "Force".



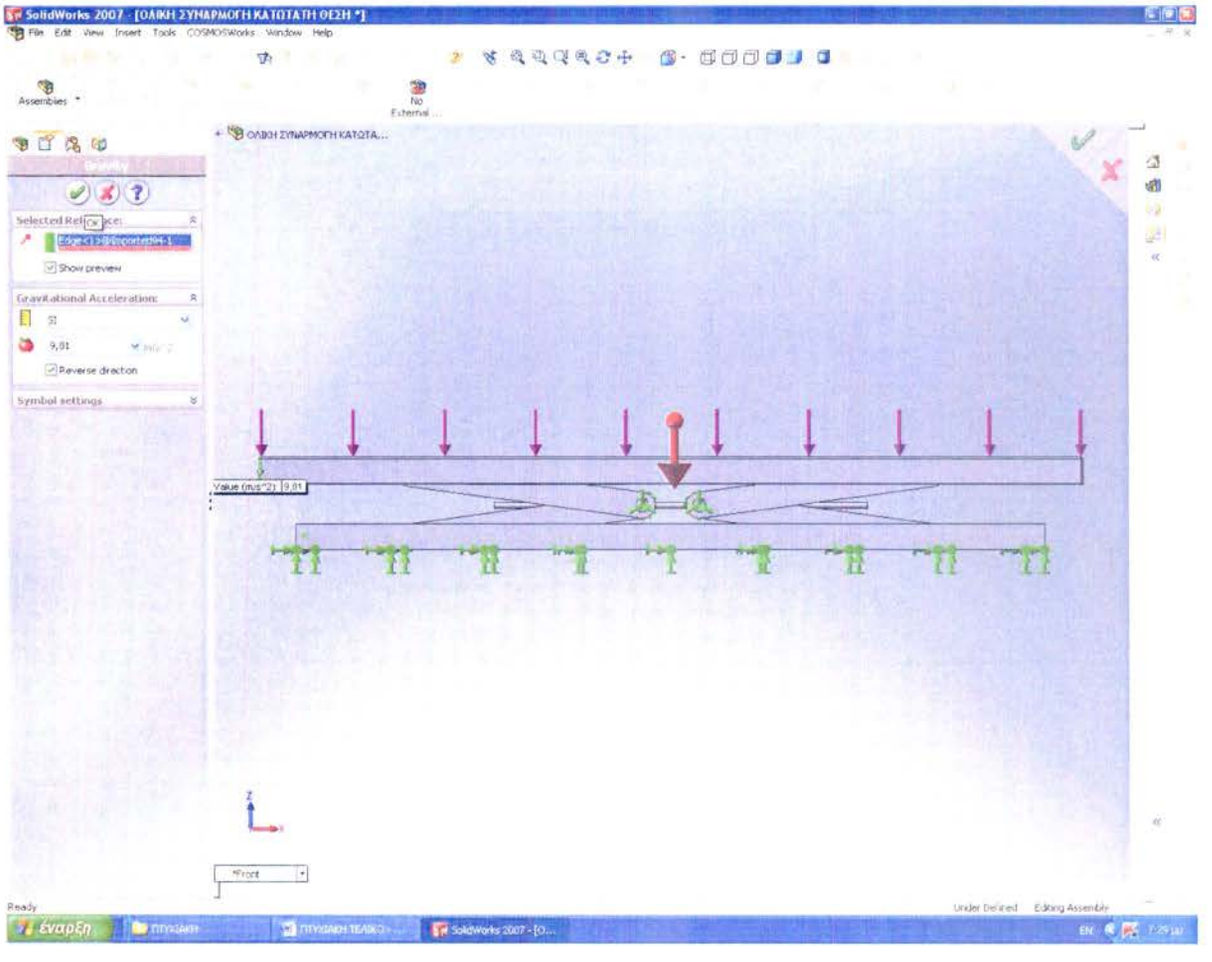
Επιλέγουμε την επιφάνεια στην οποία εφαρμόζεται το φορτίο, στη συνέχεια από τον πίνακα, που εμφανίζεται επιλέγουμε "Apply Normal Force" για ομοιόμορφη κατανομή του φορτίου στην επιφάνεια και τέλος προσδιορίζουμε το μέτρο του φορτίου.



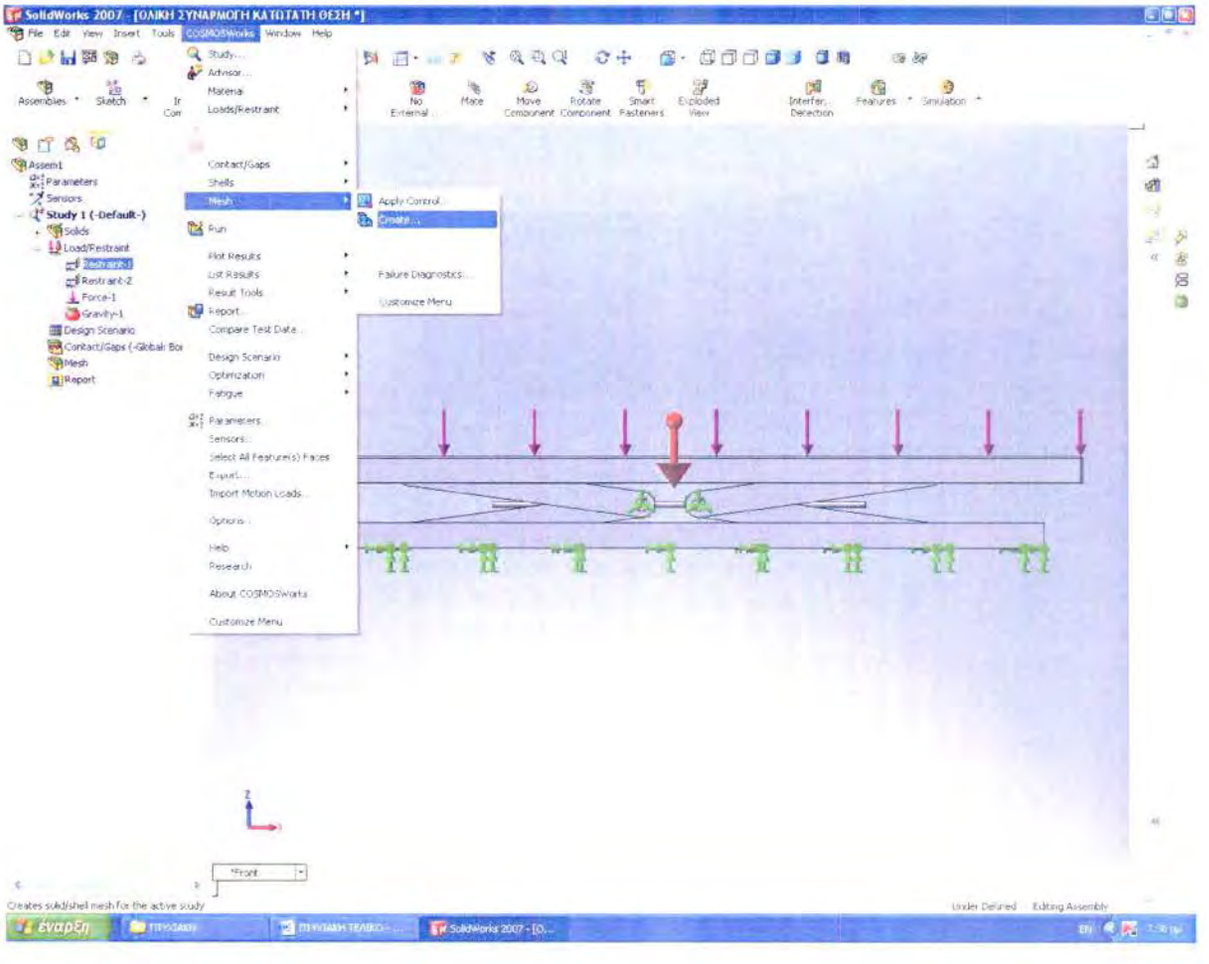
Τέλος πρέπει να επιλέξουμε την κατεύθυνση και το μέτρο της βαρύτητας, σε σχέση με την κατασκευή μας, ούτως ώστε το πρόγραμμα να συνυπολογίσει και το βάρος της κατασκευής στον στατικό έλεγχο. Από την πλατφόρμα "COSMOSWorks" επιλέγουμε "Loads/Restraint" και στη συνέχεια "Gravity".

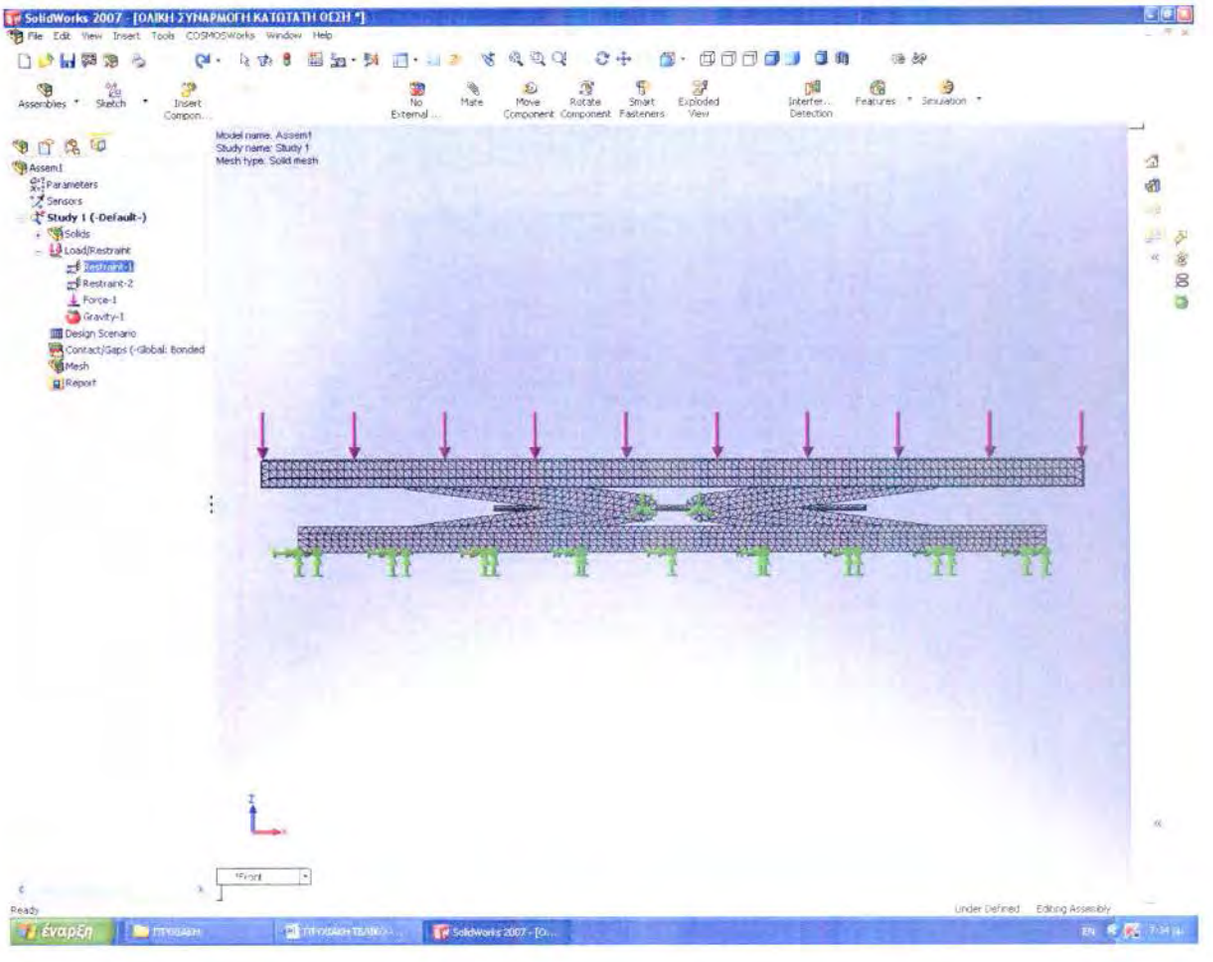


Στον πίνακα που εμφανίζεται επιλέγουμε μία ακμή της κατασκευής, με την οποία θα είναι παράλληλη η βαρύτητα, το μέτρο και τη φορά της.

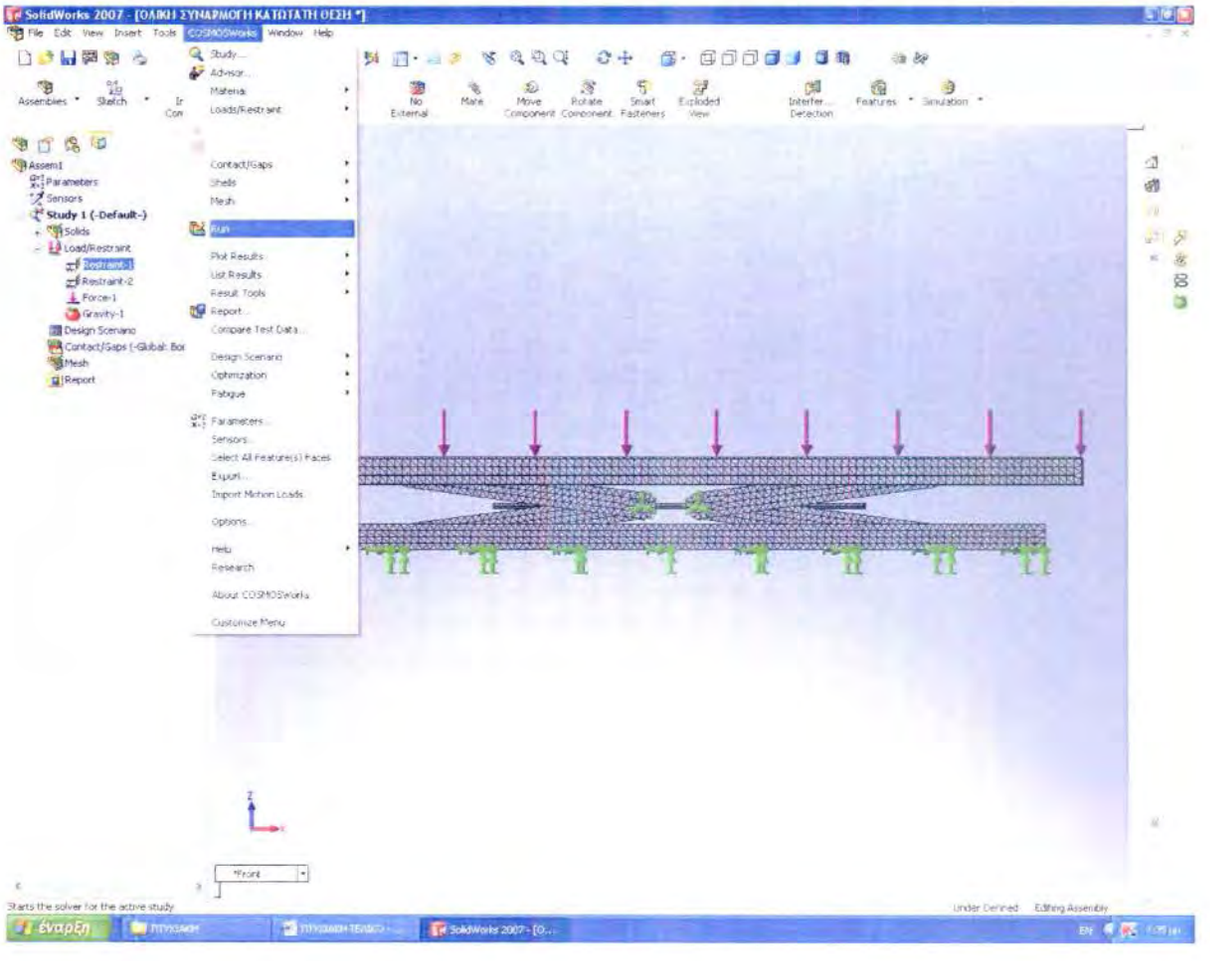


Στη συνέχεια μέσα από την πλατφόρμα "COSMOSWorks" και τις επιλογές "Mesh" και στη συνέχεια "Create", δίνουμε στο πρόγραμμα εντολή να δημιουργήσει το πλέγμα των πεπερασμένων στοιχείων, στο οποίο θα διαιρεθεί η κατασκευή, ώστε να πραγματοποιηθεί ο έλεγχος.

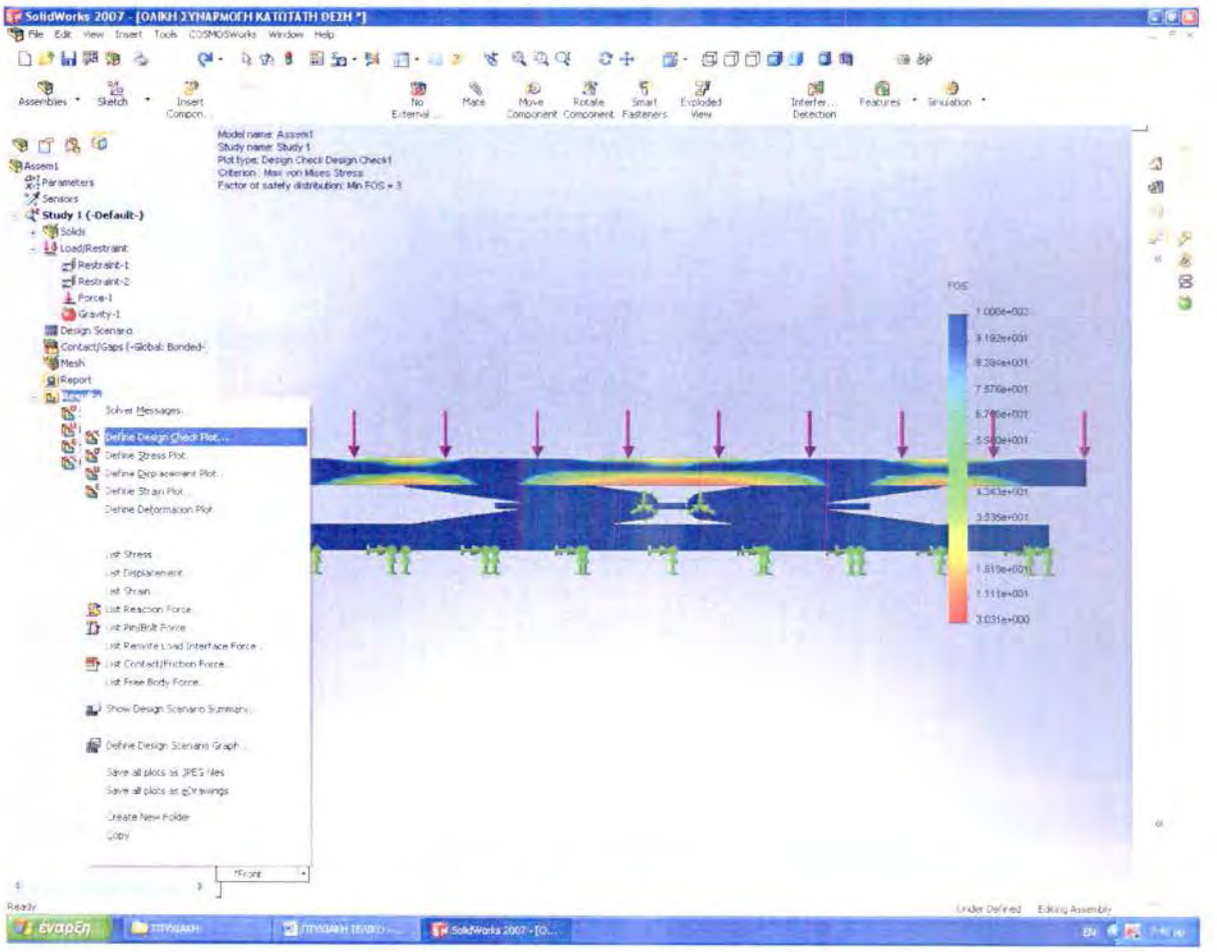



SolidWorks 2007 - [ΟΛΙΚΗ ΣΥΝΑΡΜΟΓΗ ΚΑΤΩΤΑΤΗ ΘΕΣΗ *]
File Edit View Insert Tools COSMOSWorks Window Help
Assemblies
Sketch
Insert Compon...
No External ...
Mate
Move Component
Rotate Component
Smart Fasteners
Exploded View
Interfer... Detection
Features
Simulation
Model name: Assem1
Study name: Study 1
Mesh type: Solid mesh
Assem1
Parameters
Sensors
Study 1 (-Default-)
Solids
Load/Restraint
Restraint-1
Restraint-2
Force-1
Gravity-1
Design Scenario
Contact/Gaps (-Global: Bonded
Mesh
Report
Ready
Under Defined
Editing Assembly
έναρξη

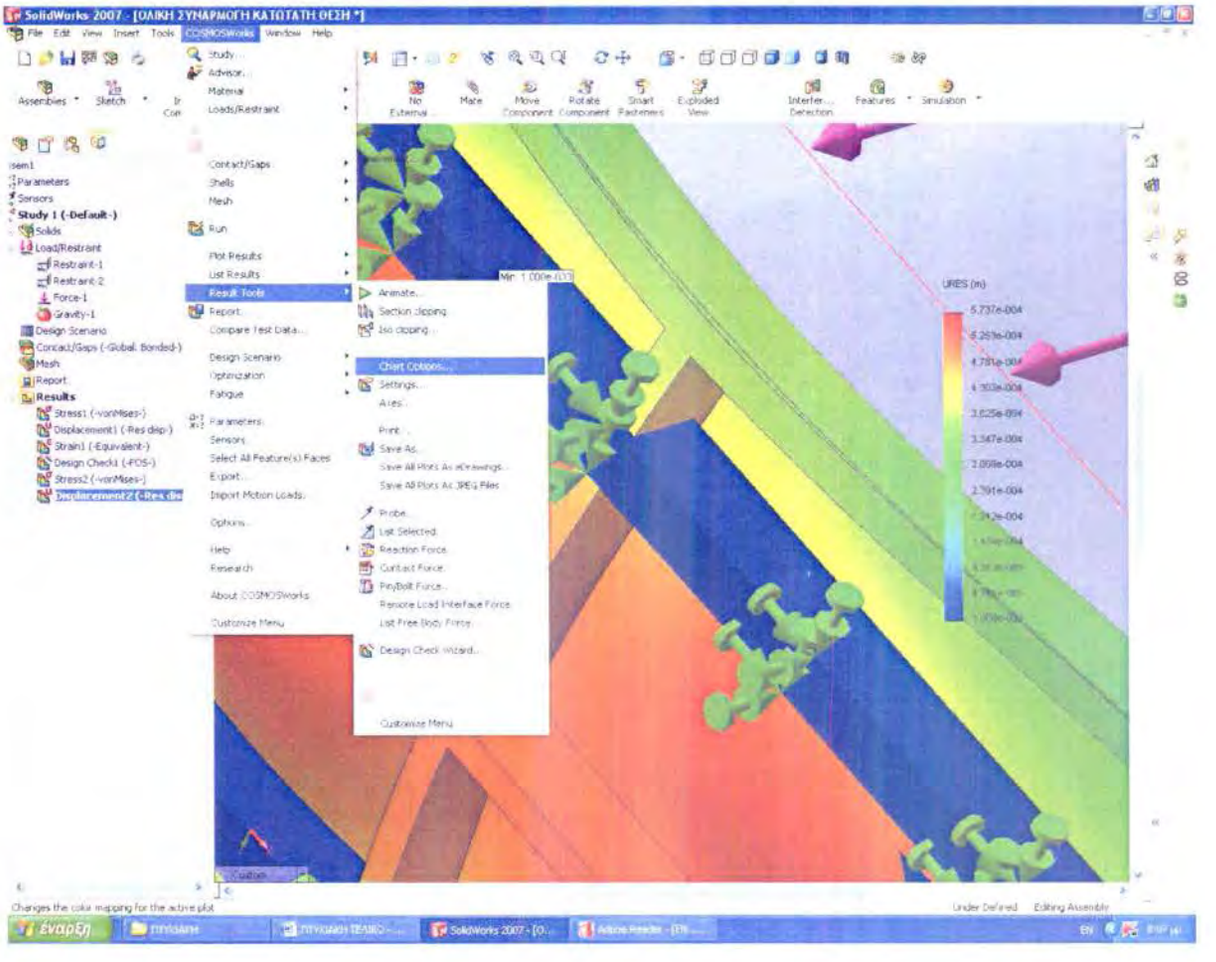
Τέλος με την επιλογή "Run" από την πλατφόρμα "COSMOSWorks" δίνουμε εντολή στο πρόγραμμα να διενεργήσει τον έλεγχο της κατασκευής, με όλες τις παραμέτρους, που ορίσαμε παραπάνω.

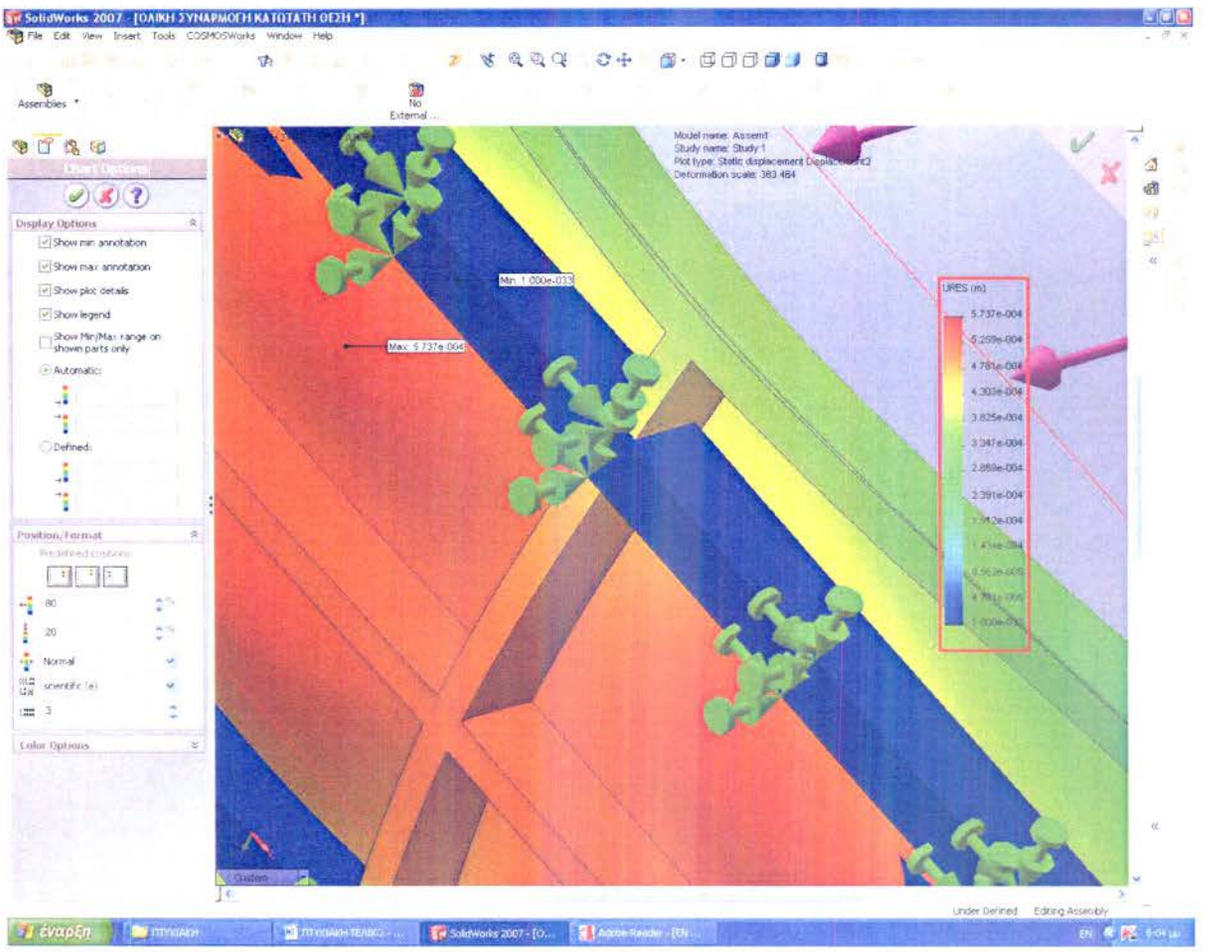


Με δεξί κλικ στο φάκελο των αποτελεσμάτων, που δημιουργεί το πρόγραμμα, εμφανίζεται ο κατάλογος με τους επιμέρους ελέγχους, που έχει διενεργήσει το πρόγραμμα. Επιλέγουμε "Define Design Check Plot" για να δούμε το συντελεστή ασφαλείας της κατασκευής. Στην προκειμένη περίπτωση ο συντελεστής είναι ίσος με 3, μέγεθος που υπερκαλύπτει τις απαιτήσεις της προδιαγραφής **EN 1493:2010** για ανυψωτικές μηχανές οχημάτων.



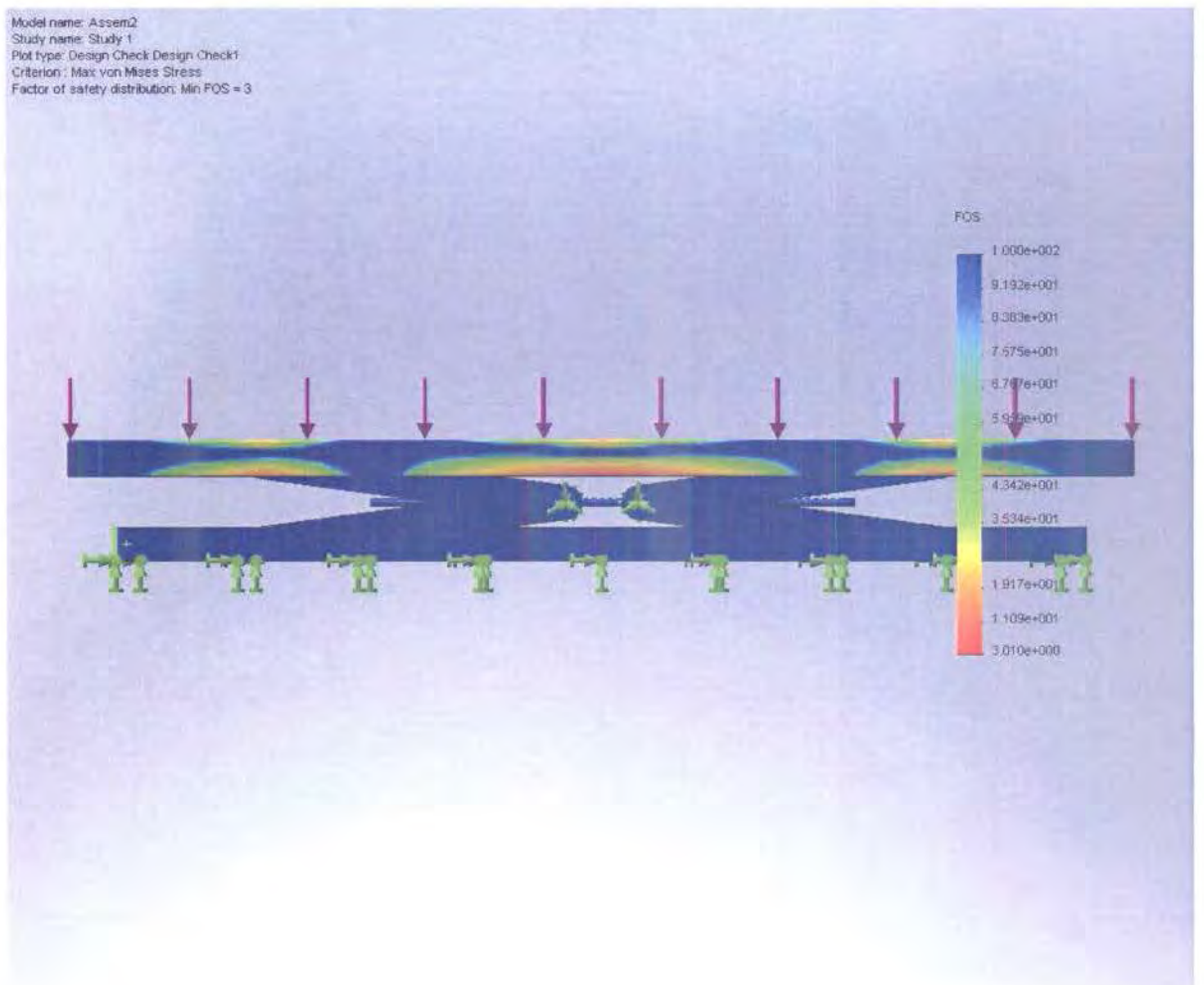
Επιπλέον από την πλατφόρμα "COSMOSWorks" έχουμε τη δυνατότητα μέσω της εντολής "Chart Options" του μενού "Result Tools", να εμφανίσουμε τα σημεία ελάχιστης και μέγιστης καταπόνησης της κατασκευής.



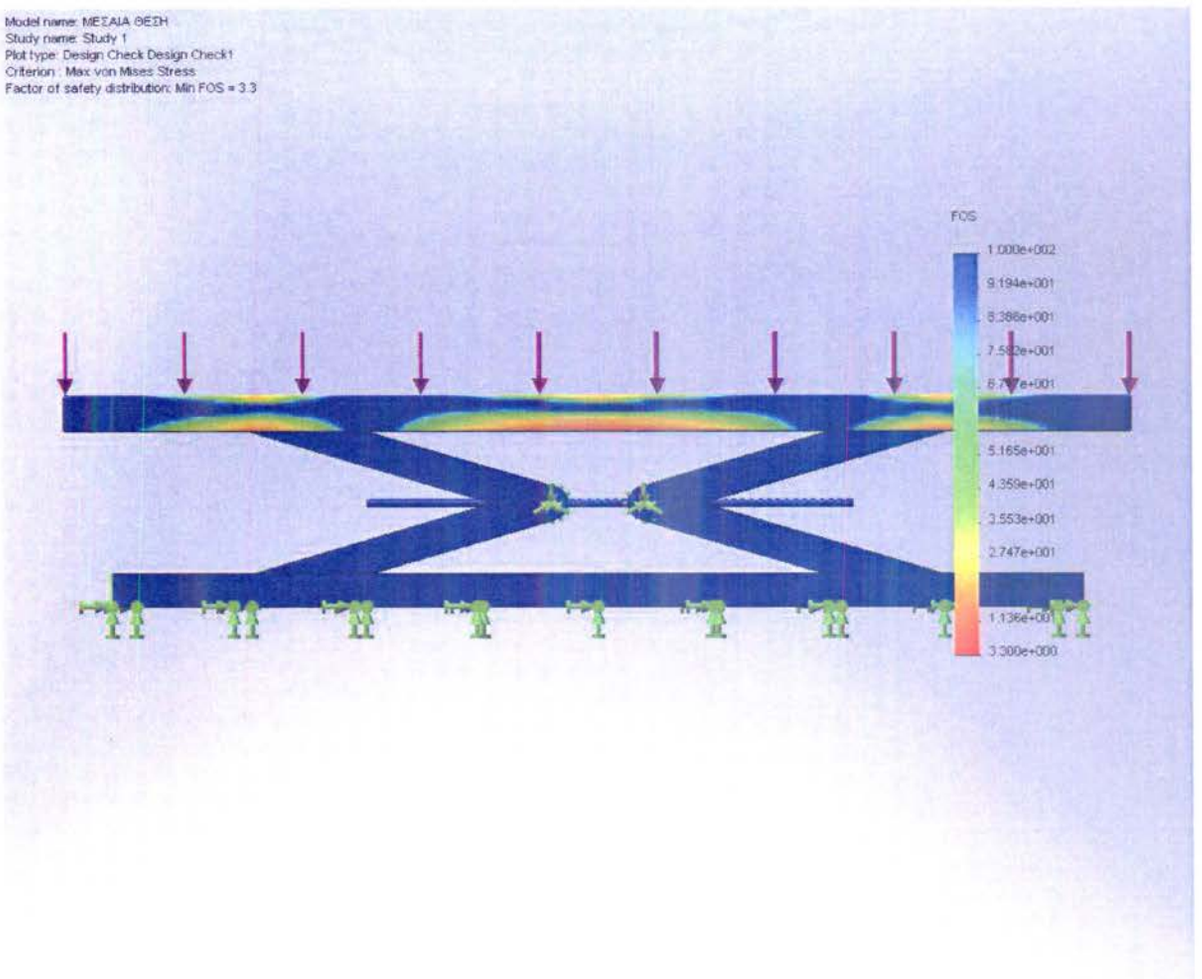

SolidWorks 2007 - [ΟΛΙΚΗ ΣΥΝΑΡΜΟΓΗ ΚΑΤΩΤΑΤΗ ΘΕΣΗ *]
File Edit View Insert Tools COSMOSWorks Window Help
Assemblies
Display Options
Show min annotation
Show max annotation
Show plot details
Show legend
Automatic:
Defined:
Position/Format
Color Options
Min: 1.000e-033
Max: 5.737e-004
URES (m)
5.737e-004
Under Defined
Editing Assembly
έναρξη

«ΣΥΜΠΕΡΑΣΜΑΤΑ»

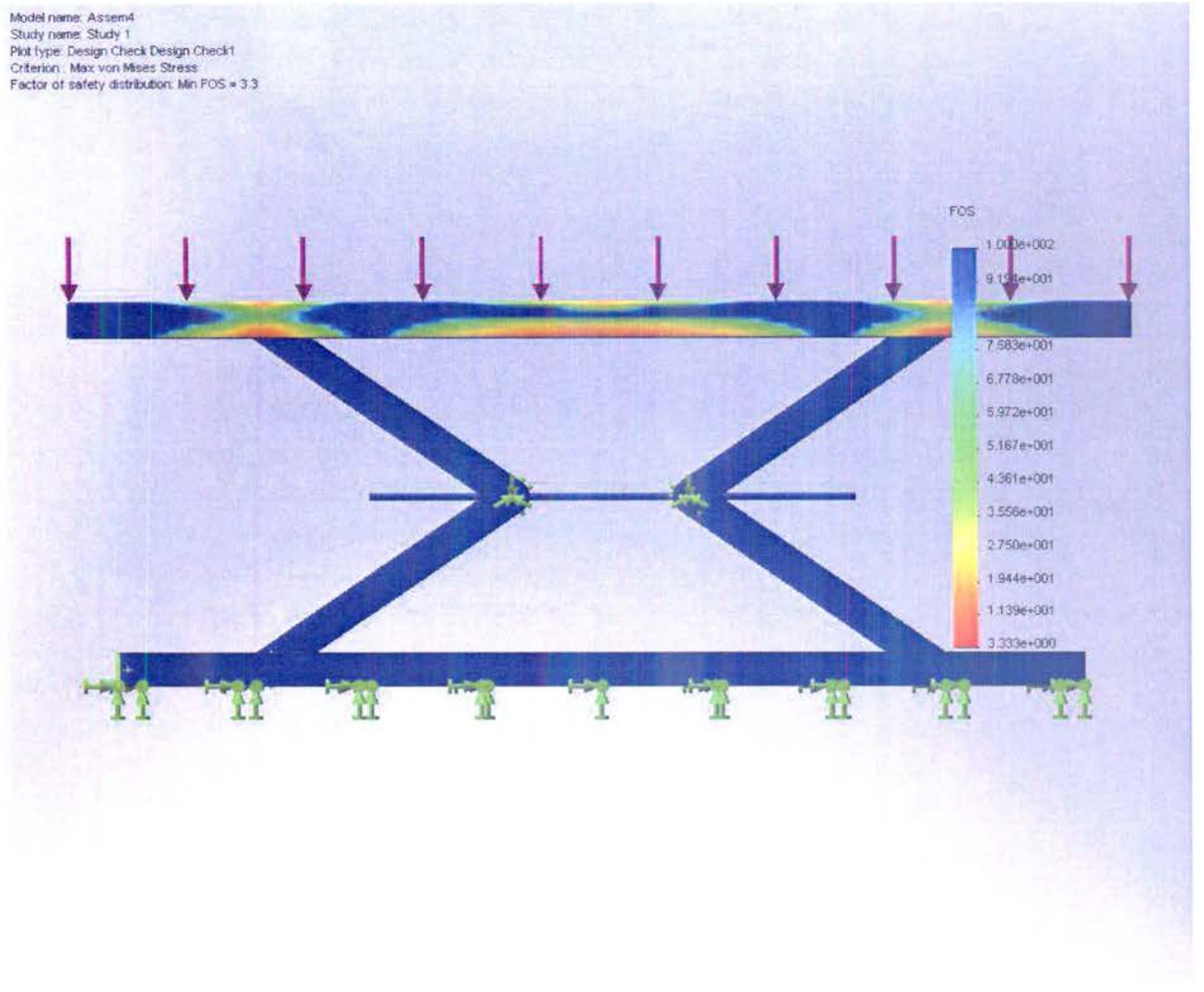
Χρήσιμο θα ήταν να κάνουμε μια σύγκριση των αποτελεσμάτων του στατικού ελέγχου της κατασκευής μας, στις τρεις θέσεις λειτουργίας. Ξεκινώντας από το συντελεστή ασφαλείας, τα αποτελέσματα για τις τρεις θέσεις λειτουργίας φαίνονται στις παρακάτω εικόνες:



Κατώτατη θέση


Model name: ΜΕΣΑΙΑ ΘΕΣΗ
Study name: Study 1
Plot type: Design Check Design Check1
Criterion : Max von Mises Stress
Factor of safety distribution: Min FOS = 3.3
FOS
1.000e+002
9.194e+001
8.388e+001
7.582e+001
5.165e+001
4.359e+001
3.553e+001
2.747e+001
1.136e+001
3.300e+000

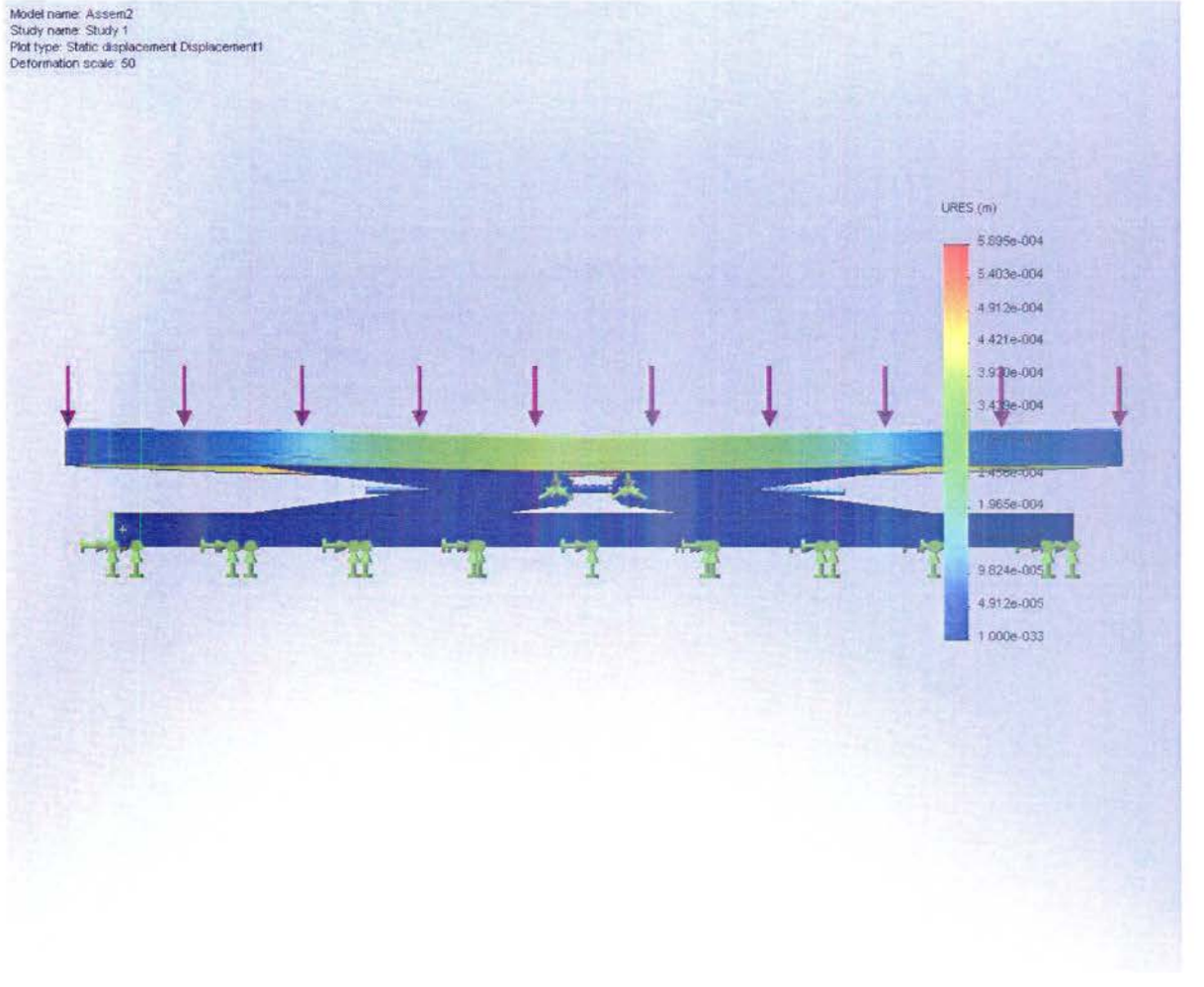
Μεσαία θέση



Ανώτατη θέση

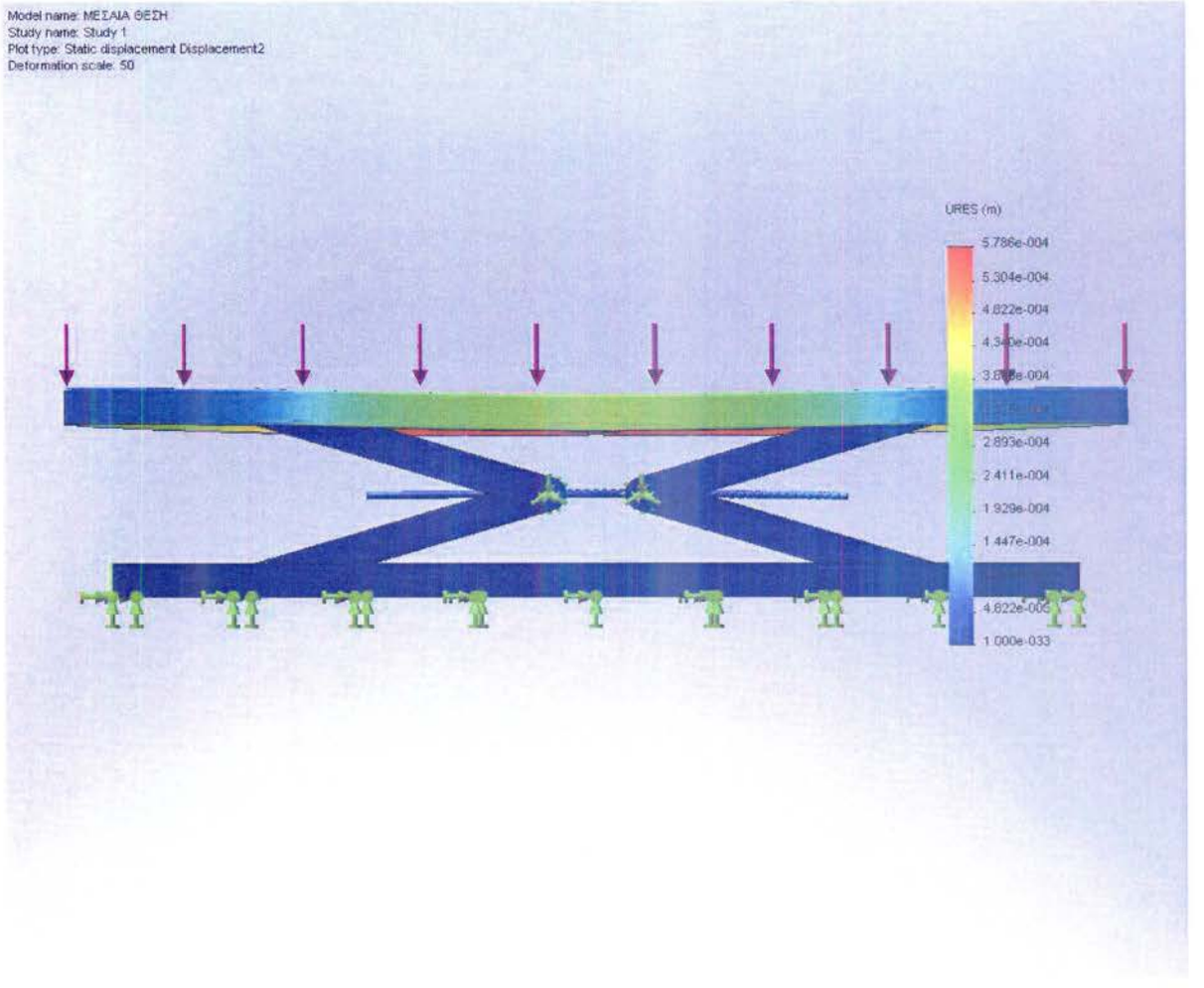
Διαισθητικά θα περίμενε κανείς ο συντελεστής ασφαλείας να είναι μεγαλύτερος στην κατώτατη θέση, λόγω κυρίως του χαμηλότερου κέντρου βάρους του συστήματος κατασκευής – φορτίου. Παρ' όλα αυτά όπως φαίνεται ο συντελεστής ασφαλείας για την μεσαία και ανώτατη θέση λειτουργίας της κατασκευής παραμένει σταθερός και ίσος με 3,3, ενώ στην κατώτατη θέση είναι ίσος με 3. Μελετώντας τα αποτελέσματα των τάσεων, που ασκούνται στην κατασκευή, καθώς και των μετατοπίσεων, θα αντιληφθούμε γιατί συμβαίνει αυτό.

Όσο αφορά τις μετατοπίσεις όπως φαίνεται στα παρκάτω σχήματα έχουμε:



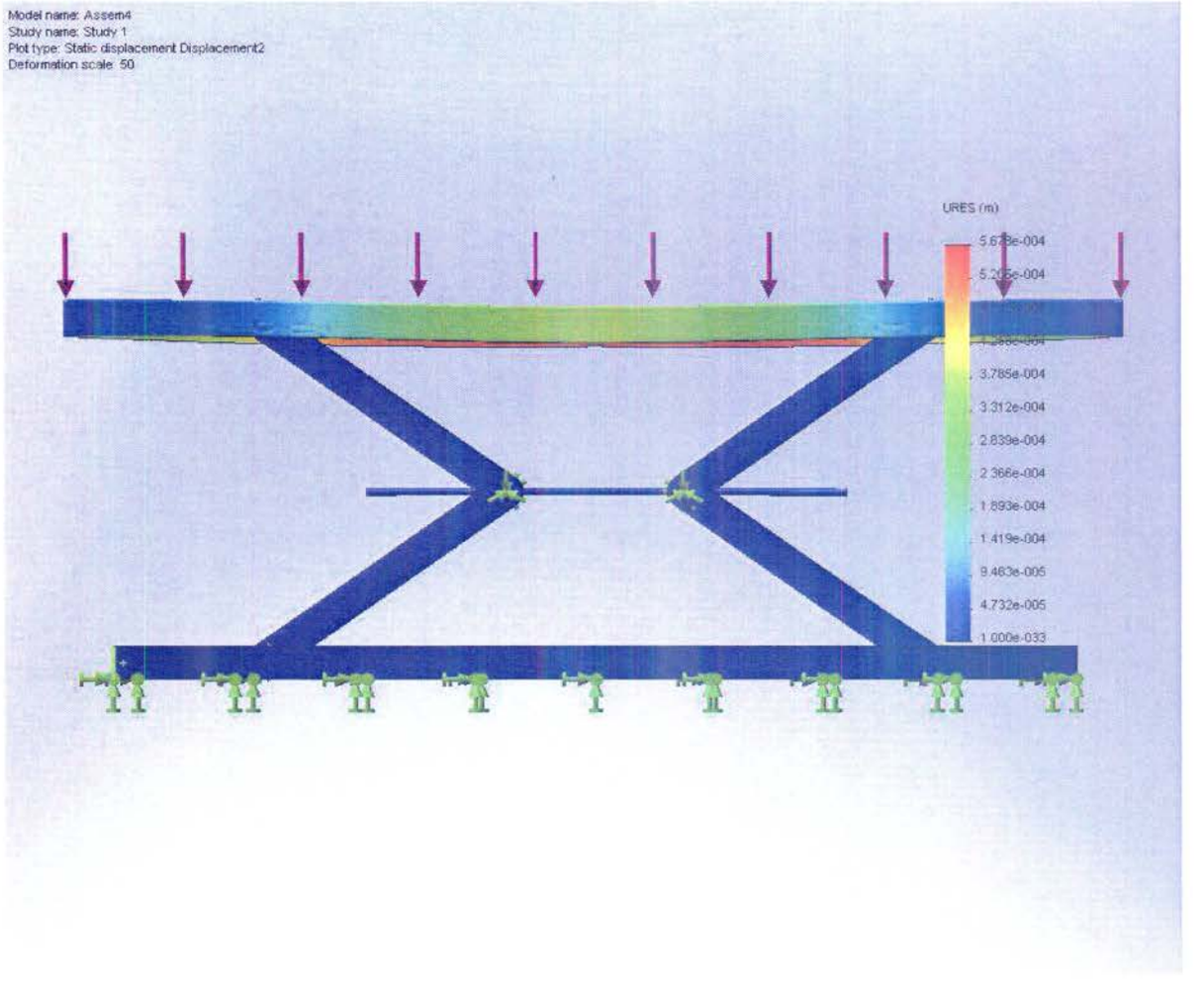
Κατώτατη θέση

Displacement1	URES: Resultant displacement	0 m Node: 10	(1930 mm, 20.0971 mm, -35 mm)	0.000589468 m Node: 191109	(710.767 mm, 141.51 mm, 211.002 mm)



Μεσαία θέση

Displacement1	URES: Resultant displacement	0 m Node: 10	(1930 mm, 20.0971 mm, -35 mm)	0.000578631 m Node: 174669	(720.138 mm, 144.729 mm, 399.967 mm)

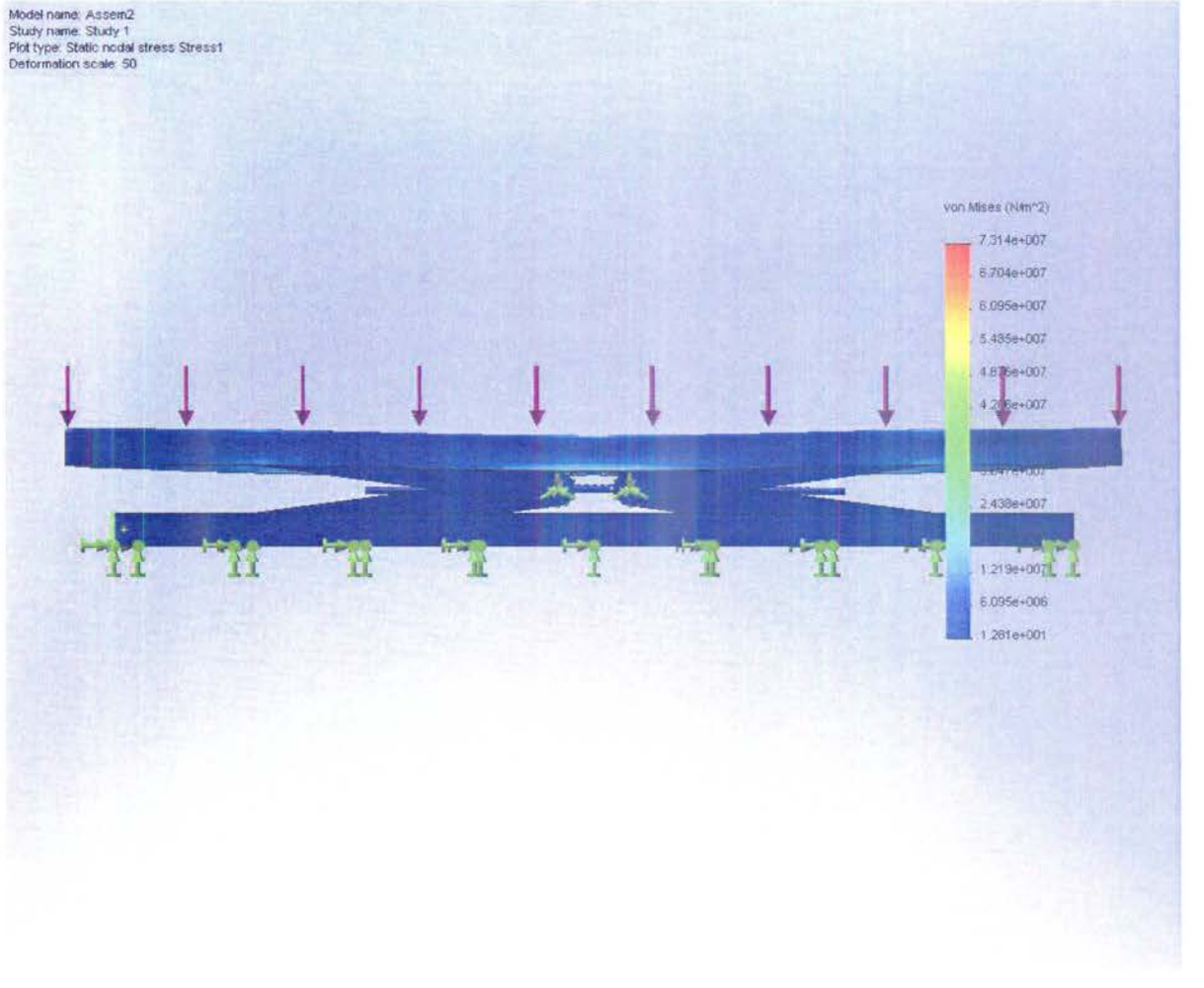


Ανώτατη θέση

Displacement2	URES: Resultant displacement	0 m Node: 10	(1930 mm, 20.0971 mm, -35 mm)	0.000567793 m Node: 93360	(1246.59 mm, 395.334 mm, 767.706 mm)

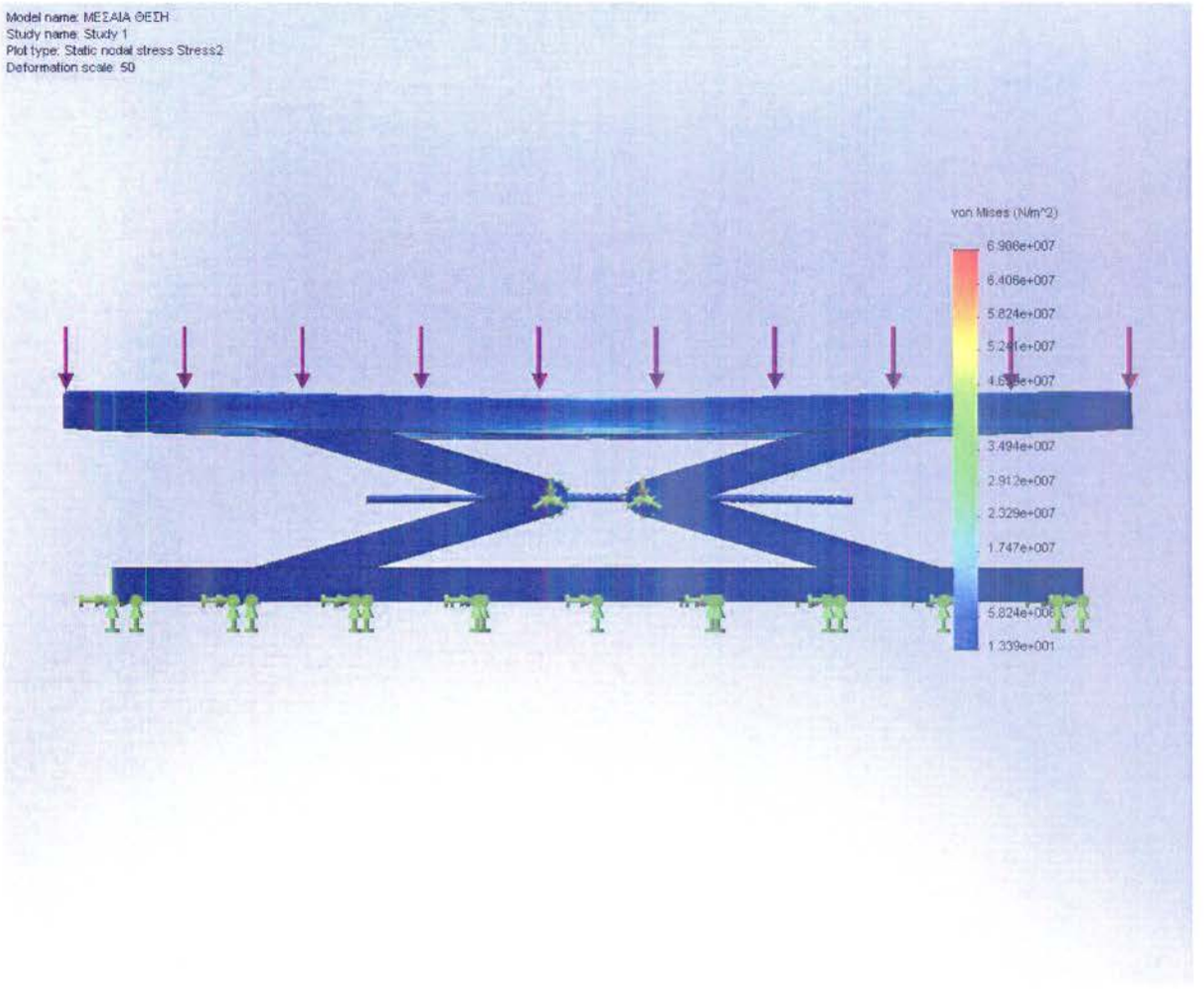
Οι μετατοπίσεις όπως αναμενόταν σύμφωνα με τα αποτελέσματα του συντελεστή ασφαλείας είναι μεγαλύτερες στην κατώτατη θέση λειτουργίας. Η διαφορά στις μετατοπίσεις, μεταξύ των θέσεων λειτουργίας είναι της τάξης του $1*10^{-5}$ m, δηλαδή πρακτικά αμελητέα.

Τέλος τα αποτελέσματα για τις τάσεις, που δέχεται η κατασκευή, φαίνονται στις παρακάτω εικόνες:



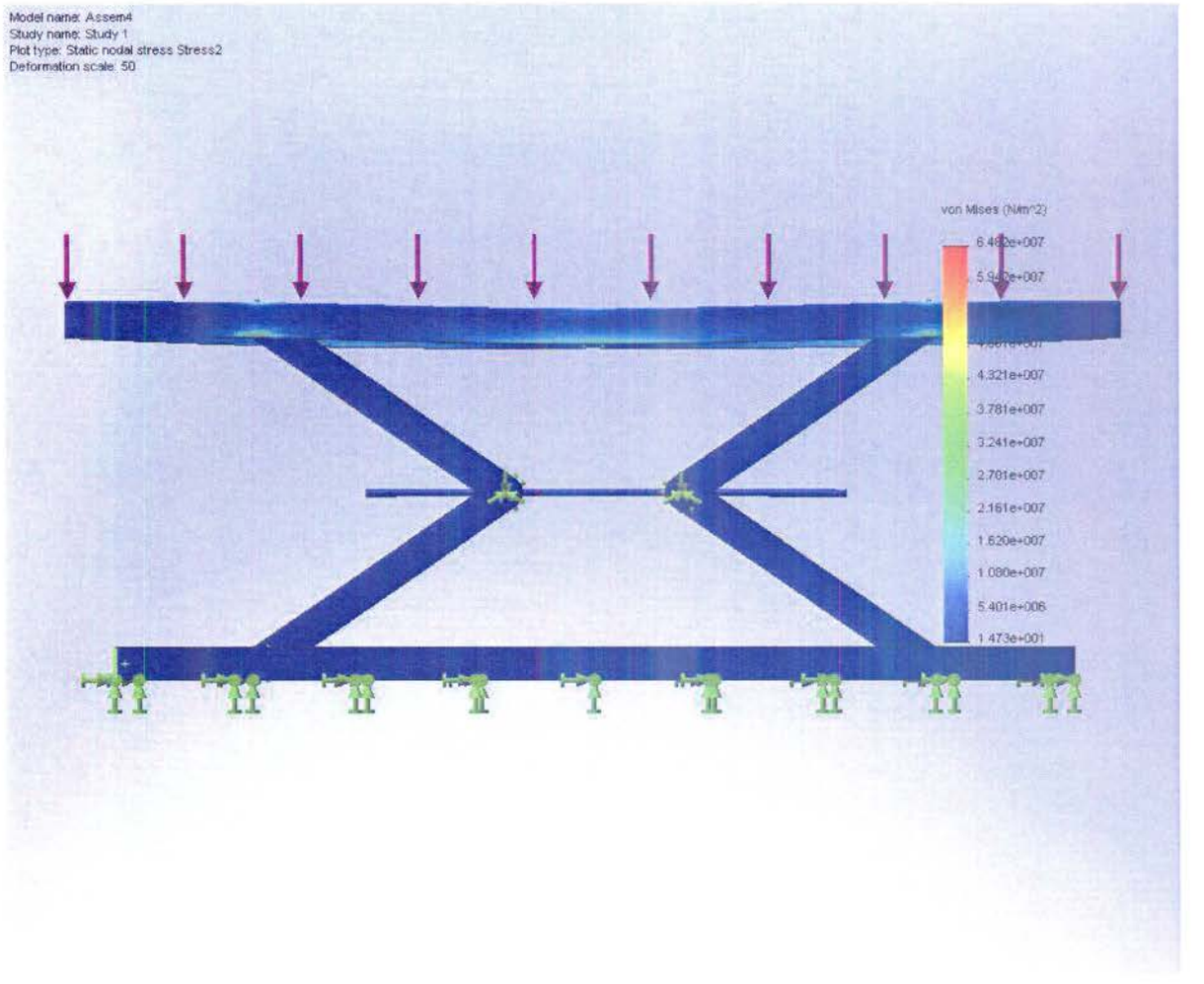
Κατώτατη θέση

Stress1	VON: von Mises stress	12.8145 N/m^2 Node: 213576	(1955 mm, 486.954 mm, -35 mm)	7.31378e+007 N/m^2 Node: 217321	(1682.28 mm, 26.2881 mm, 153.651 mm)



Μεσαία θέση

Stress1	VON: von Mises stress	13.3935 N/m^2 Node: 3491	(658 mm, -4.90291 mm, -35 mm)	6.98838e+007 N/m^2 Node: 198969	(1682.28 mm, 25.9341 mm, 342.617 mm)



Ανώτατη θέση

Stress1	VON: von Mises stress	14.7299 N/m^2 Node: 16495	(928.626 mm, 545.097 mm, -30 mm)	6.48168e+007 N/m^2 Node: 149560	(1683.41 mm, 515.472 mm, 705.543 mm)

Καταρχήν όπως φαίνεται στις παραπάνω εικόνες και είναι εντελώς φυσιολογικό, οι μεγαλύτερες μετατοπίσεις εντοπίζονται στα σημεία που έχουμε και τις μεγαλύτερες τάσεις. Επιπλέον όπως και στις μετατοπίσεις το μέγεθος των τάσεων ακολουθεί φθίνουσα πορεία από την κατώτατη έως την ανώτατη θέση λειτουργίας. Εντύπωση προκαλεί το γεγονός ότι ένα φορτίο της τάξης των 10.000 N, προκαλεί σε συγκεκριμένα σημεία τάσεις της τάξης των 70.000.000 N/m^2.

Γενικά η εκπόνηση της πτυχιακής αυτής εργασίας ήταν μια πολύ σημαντική εμπειρία, αφού καταλήξαμε σε κάποια καίρια, για τον μελλοντικό τρόπο σκέψης μας ως μηχανολόγοι, συμπεράσματα. Βιώσαμε πως η συστηματοποίηση απλών διαδικασιών, μπορεί να οδηγήσει στην κατασκευή λειτουργικών και ασφαλών μηχανών. Ο «σχεδιασμός των κατασκευών» συνδυάζοντας την απλή ανθρώπινη λογική, με την κατασκευαστική εμπειρία και τις σύγχρονες τεχνικές συστηματοποίησης διαδικασιών, οδηγεί ακόμα και ένα όχι τόσο έμπειρο μηχανικό, στη δημιουργία επιτυχημένων κατασκευών. Η φιλοσοφία της διαδικασίας αυτής, δεν περιορίζεται μόνο στην μηχανολογία. Μέσα από την ενασχόληση με το σχεδιασμό των κατασκευών εξοικειώνεσαι με ένα ορθολογικό τρόπο σκέψης, ο οποίος βοηθάει σημαντικά ακόμα και στην αντιμετώπιση απλών καθημερινών προβλημάτων, τα οποία ουδεμία σχέση έχουν με τη μηχανολογία. Η συστηματοποίηση δεν εγκλωβίζει τη σκέψη, αντίθετα συνειδητά την απελευθερώνει και την οδηγεί προς όλες τις κατευθύνσεις. Επίσης πολύ σημαντική ήταν και εξοικείωσή μας με τα σύγχρονα, τρισδιάστατα προγράμματα σχεδιασμού και μελέτης των κατασκευών.

Όσο αφορά αυτό καθ' αυτό το σχεδιασμό της συγκεκριμένης κατασκευής, μας εντυπωσίασε το γεγονός ότι ακολουθώντας συγκεκριμένες μεθόδους, νόμους και κανονισμούς, σχεδιάσαμε μια μηχανή, η οποία αποδείχτηκε από τον έλεγχο ικανή να ανταπεξέλθει στις λειτουργικές απαιτήσεις.

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ΠΑΡΑΡΤΗΜΑ

1. ΣΧΕΤΙΚΕΣ ΠΡΟΔΙΑΓΡΑΦΕΣ

Προδιαγραφή EN 1493:2010

BS EN 1493:2010
Vehicle lifts

BS EN 1493:2010 BRITISH STANDARD

National foreword

This British Standard is the UK implementation of EN 1493:2010. It supersedes BS EN 1493:1999+A1:2008 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee MHE/12/-/3, Lifting Platforms - Vehicle lifting devices.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Compliance with a British Standard cannot confer immunity from legal obligations.

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Amendments issued since publication

Date Text affected

BS EN 1493:2010

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1493

August 2010
ICS 43.180; 53.020.99 Supersedes EN 1493:1998+A1:2008

English Version

Vehicle lifts

Elévateurs de véhicules Fahrzeug-Hebebühnen

This European Standard was approved by CEN on 26 June 2010.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation

Ref. No. EN 1493:2010: E

Contents Page

Foreword

This document (EN 1493:2010) has been prepared by Technical Committee CEN/TC 98 "Lifting platforms",
the secretariat of which is held by DIN.
This European Standard shall be given the status of a national standard, either by publication of an identical
text or by endorsement, at the latest by February 2011, and conflicting national standards shall be withdrawn
at the latest by February 2011.
Attention is drawn to the possibility that some of the elements of this document may be the subject of patent
rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.
This document supersedes EN 1493:1998+A1:2008.
This document has been prepared under a mandate given to CEN by the European Commission and the
European Free Trade Association, and supports essential requirements of EU Directive(s).
For relationship with EU Directive(s), see informative Annex ZA, which is an integral part of this document.
According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following
countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech
Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia,
Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain,
Sweden, Switzerland and the United Kingdom.

Introduction

This document is a type C standard as stated in EN ISO 12100-1:2003.
The machinery concerned and the extent to which hazards, hazardous situations and hazardous events are
covered are indicated in the scope of this document. In addition, machinery should comply as appropriate with
EN ISO 12100-1 for hazards which are not covered by this standard.
When provisions of this type C standard are different from those which are stated in type A or B standards, the
provisions of this type C standard take precedence over the provisions of the other standards, for machines
that have been designed and built according to the provisions of this type C standard.
The object of this European Standard is to define rules for safeguarding persons against the risk of accidents
associated with the operation of vehicle lifts.
While elaborating this standard it was assumed that only authorized persons operate the vehicle lifts and that
the working area is sufficiently lit.
The requirement concerning loading control is not deemed pertinent to this standard insofar as:
| experience and the state of the art suggests that failing to observe this requirement has not historically
given rise to unsafe situations;
| such devices which would give protection against overall and local overloading are not currently available
in forms which cover all eventualities;
| the weight and weight distribution is freely available for the type of vehicles to be lifted and as such it is
the responsibility of the user to prevent an unsafe situation arising;
| vehicle lifts are generally designed to suit the maximum weight of vehicle to which it would reasonably be
subjected, hence the normal duty of a lift is substantially lower than the maximum.

1 Scope

This European Standard applies to stationary, mobile and movable vehicle lifts, which are not intended to lift
persons but which are designed to raise vehicles totally, for the purpose of examining and working on or under
the vehicles whilst in a raised position. The vehicle lift may consist of one or more lifting-units.
Power supply to the vehicle lift by internal combustion engines is not considered.
The floor or ground supporting the vehicle lift in use is assumed to be horizontal.
This document is applicable to vehicle lifts which are manufactured ½ year after the date of its publication as
EN.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated
references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.
EN 982:1996+A1:2008, *Safety of machinery — Safety requirements for fluid power systems and their*

components — Hydraulics
EN 983:1996+A1:2008, *Safety of machinery — Safety requirements for fluid power systems and their*
components — Pneumatics
EN 60204-1:2006, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*
(IEC 60204-1:2005, modified)
EN 60204-32:2008, *Safety of machinery — Electrical equipment of machines — Part 32: Requirements for*
hoisting machines (IEC 60204-32:2008)
EN 60529:1991, *Degrees of protection provided by enclosures (IP Code) (IEC 60529:1989)*
EN 60947-5-1:2004, *Low-voltage switchgear and controlgear — Part 5-1: Control circuit devices and switching*
elements — Electromechanical control circuit devices (IEC 60947-5-1:2003)
EN ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1: Basic*
terminology, methodology (ISO 12100-1:2003)
EN ISO 12100-2:2003, *Safety of machinery — Basic concepts, general principles for design — Part 2:*
Technical principles (ISO 12100-2:2003)
EN ISO 13849-1:2008, *Safety of machinery — Safety-related parts of control systems — Part 1: General*
principles for design (ISO 13849-1:2006)
EN ISO 13849-2:2008, *Safety of machinery — Safety-related parts of control systems — Part 2: Validation*
(ISO 13849-2:2003)
EN ISO 13850:2008, *Safety of machinery — Emergency stop — Principles for design (ISO 13850:2006)*
ISO 4308-1:2003, *Cranes and lifting appliances — Selection of wire ropes — Part 1: General*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 12100-1:2003 and the following
apply.

3.1

vehicle lift

lifting device with guided load carrying device for lifting land based means of transport such as cars, motorcycles, lorries, buses, trams, rail vehicles, industrial trucks and similar, in the following named vehicle,
and designed for working on or under the load
NOTE 1 The guidance of the load carrying device is given by the supporting structure.
NOTE 2 A vehicle lift may have the ability to tilt the load carrying device about a horizontal axis parallel to or perpendicular to the main axis of the lifted vehicle.
NOTE 3 The following types of vehicle lift are examples of those covered by this definition: single and multi-column
lifts, single and multi-cylinder lifts, mobile column lifts, scissor and parallelogram lifts, short stroke lifts, which support
vehicle wheels, chassis or other designated lifting points (see Annex B (informative)).
NOTE 4 Short stroke lifts are floor mounted vehicle lifts with a maximum vertical travel of not more than 500 mm, which
are not designed for working under the raised load.

3.2

manually driven vehicle lift

vehicle lift where the load carrying device is driven by manual effort

3.3

power-driven vehicle lift

vehicle lift where the load carrying device is not driven by manual effort

3.4

fixed vehicle lift

vehicle lift fixed permanently to its location

3.5

movable vehicle lift

vehicle lift which can fulfil its function without being fixed to the floor and may be designed to be transportable

3.6

mobile vehicle lift

movable vehicle lift equipped with wheels, rollers, etc. such that it can be moved from one place to another
with or without load

3.6.1

manually mobile vehicle lift

mobile vehicle lift which is moved by manual effort alone

3.6.2

vehicle lift with powered mobility

mobile vehicle lift which is not moved by manual effort

3.7

initial position

lower limit position of the carrying device

3.8

rated load

maximum load that a lift has been designed to carry referring to the normative vehicle or to special vehicles
mentioned in 5.7.4.4

3.9

load carrying device

part(s) of the vehicle lift which supports the load either by direct contact with the vehicle or through contact
with pick-up plates or pads

EXAMPLE Tracks, carrying arms or other mechanical devices designed to raise and support a vehicle by designated
lifting points.

3.10

carrying arm

load carrying device attached at one end, directly or indirectly to the lifting element and supporting the load at
its other end

NOTE Carrying arms are usually used on two column lifts.

3.11

pick-up plate

part of the load carrying device, e.g. on two column lifts with carrying arms, which has direct contact to the
vehicle and which has an assigned position on the load carrying device
NOTE See Figure 1.

3.12

pick-up pad

vehicle supporting pad which has direct contact with the vehicle but which does not have an assigned
position, e.g. pads used on wheel free systems with platforms
NOTE See Figure 2.

Key

1 pick-up plate
2 load carrying device
3 pin

Figure 1 — Pick-up plate

Key

1 pick-up pad
2 platform

Figure 2 — Pick-up pad

3.13

lifting element

medium through which the force is transmitted from the power source to the load carrying device
NOTE Lifting elements include hydraulic and pneumatic cylinders, lead screw and nut systems as well as any flexible
connections such as steel wire ropes and chains.

3.14

catching device

device which holds the load carrying device in case of failure of the lifting element

3.15

re-raising prevention device

device which prevents re-raising of load carrying device from the initial position in the event of failure of the
lifting element

3.16

unauthorised use

use by a person who has not received permission to operate the lift and instruction on its safe operation

3.17

braking

3.17.1

automatic brake

braking device which is normally held on and which is released only by application of power

NOTE Operation is also instigated automatically by releasing the lift controls and by interruption of the power supply.

3.17.2

self braking system

system which, due to its inherent resistance to movement, stops the movement of the load carrying device
when the drive power is interrupted

3.18

safety switch

switch in which the opening contacts are directly connected to the control mechanism without springs or
flexible elements

NOTE The whole of the specified opening of the contacts should be achieved by operation of the control mechanism
through its intended travel using the force stated by the manufacturer of the switch (see K.2.1 of EN 60947-5-1:2004).

3.19

normative vehicle

road vehicle used for calculations in 5.7

3.20

wheel track

distance between the centre lines of the wheels on one axle or between centre lines of wheel pairs on twin
wheel axles

3.21

wheel base

distance between the centres of wheels of front and rear axle or from the centre of the wheels on the front
axle to a point mid way between axle pairs on twin axle vehicles

3.22

multiple lifting units

combination of independent couples of mobile column lifts or two or more vehicle lifts

3.23

wheel free system

lifting unit which is used in conjunction with a pit or vehicle lift with platform lifting the whole vehicle and allows
the wheels to be removed

4 List of hazards

Table 1 contains a list of hazards which are applicable in the situations described and could involve risks to
persons if not reduced or eliminated. The corresponding requirements are designed to limit the risk or reduce
these hazards in each situation.

"Not applicable" in Table 1 means that this hazard does not exist on vehicle lifts.

"Not significant" in Table 1 means that this hazard can exist on vehicle lifts, but it causes no risk to persons.

Table 1 — List of hazards

Hazards	Corresponding Requirement
1 Mechanical hazards	**5.7, 5.9, 5.17.1**
1.1 Crushing hazards	5.3.1, 5.6.1, 5.6.2, 5.17
1.2 Shearing hazard	5.3.1, 5.6.1, 5.6.2, 5.17
1.3 Cutting or severing hazard	5.8.3.3, 5.18
1.4 Entanglement hazard	5.4.3
1.5 Drawing-in or trapping hazard	5.4.4
1.6 Impact hazard	5.5, 5.8.3.1, 5.8.3.2, 5.11, 5.12, 5.13, 5.14
1.7 Stabbing or puncture hazard	not applicable
1.8 Friction or abrasion hazard	not applicable
1.9 High pressure fluid injection hazard	5.8.4.2, 5.8.4.4, 5.19.3
1.10 Ejection of parts (of machinery and processed materials/work pieces)	not applicable
1.11 Loss of stability (of machinery and machine parts)	5.7.6
1.12 Slip, trip and fall hazards in relationship with machinery (because of their mechanical nature)	5.10
2 Electrical hazards	
2.1 Electrical contact direct or indirect	5.21.1, 5.21.3
2.2 Electrostatic phenomena	not applicable
2.3 Thermal radiation or other phenomena such as ejection of molten particles, and chemical effects from short-circuits, overloads etc.	not applicable
2.4 External influences on electrical equipment	5.21.1
3 Thermal hazards resulting in:	
3.1 Burns and scalds, by a possible contact of persons, by flames or explosions and also by the radiation of heat sources	not applicable
3.2 Health damaging effects by hot or cold work environment	not applicable
4 Hazards generated by noise	
4.1 Hearing losses (deafness), other physiological disorders (e.g. loss of balance, loss of awareness, etc.)	see Annex G

Table 1 — List of hazards *(continued)*

Hazards	Corresponding Requirement
4.2 Interferences with speech communication, acoustic signals, etc.	not applicable

5 Hazards generated by vibration (resulting in a variety of neurological and vascular disorders)

not applicable

6 Hazards generated by radiation, especially by:

6.1 Electrical arcs not applicable
6.2 Lasers not significant
6.3 Ionising radiation sources not applicable
6.4 Machines making use of high frequency electromagnetic fields
not applicable

7 Hazards generated by materials and substances processed, used or exhausted by machinery

7.1 Hazards resulting from contact with or inhalation of harmful fluids, gases, mists, fumes and dust
5.8.4
7.2 Fire or explosion hazard not applicable
7.3 Biological and microbiological (viral or bacterial) hazards not applicable

8 Hazards generated by neglecting ergonomic principles in machine design (mismatch of machinery with human characteristics and abilities) caused for example by:

5.4, 5.16.3

8.1 Unhealthy postures or excessive efforts 5.16.5, 5.20
8.2 Inadequate consideration of human hand-arm or foot-leg anatomy
5.4.1
8.3 Neglected use of personal protection equipment not applicable
8.4 Inadequate area lighting not applicable
8.5 Mental overload or underload, stress, etc. not applicable
8.6 Human error 5.2, 5.3.1, 5.3.2, 5.3.3, 5.3.4, 5.3.5

9 Hazards combinations not applicable

10 Hazards caused by failure of energy supply, breaking down of machinery parts and other functional disorders

10.1 Failure of energy supply (of energy and/or control circuits). 5.8.4.5, 5.8.4.6, 5.8.4.7, 5.8.5.5, 5.8.5.6, 5.8.5.7, 5.14
10.2 Unexpected ejection of machine parts or fluids 5.8.4.3, 5.8.4.8, 5.8.5.2, 5.8.5.3, 5.8.5.4
10.3 Failure/disorder of control system (unexpected start up, unexpected overrun)
5.3.1, 5.8.1
10.4 Errors of fitting 7.3.1
10.5 Overturn, unexpected loss of machine stability 5.7.6

11 Hazards caused by (temporary) missing and/or incorrect positioned safety related measures/means

11.1 All kinds of guard 5.10, 5.17.3

Table 1 — List of hazards *(continued)*

Hazards Corresponding Requirement

11.2 All kinds of safety related (protection) devices 5.7.5.1, 5.17.3, 5.18

11.3 Starting and stopping devices 5.8.2
11.4 Safety signs and tags 5.3.4
11.5 All kinds of information or warning devices 7.2, 7.3
11.6 Energy supply disconnecting devices 5.21.1, 5.21.2, 5.21.3
11.7 Emergency devices 5.4.5
11.8 Feeding/removal means of work pieces not applicable
11.9 Essential equipment and accessories for safe adjusting and/or maintaining
7.3
11.10 Equipment evacuating gases, etc. not applicable

HAZARDS DUE TO MOBILITY

12 Inadequate lighting of moving/working area 5.4.1, 5.4.3

13 Hazards due to sudden movement, instability etc. during handling

5.16.1, 5.16.2

14 Inadequate/inergonomic design of driving/operating position

5.4.1

14.1 Hazards due to dangerous environments (contact with moving parts, exhaust gases, etc.)
not applicable
14.2 Inadequate visibility from driver's/operator's position not applicable
14.3 Inadequate seat/seating (seat index point) not applicable
14.4 Inadequate/inergonomic design/positioning of controls 5.4.1
14.5 Starting/moving of self-propelled machinery 5.16.1, 5.16.2
14.6 Road traffic of self-propelled machinery not applicable
14.7 Movement of pedestrian controlled machinery 5.16.3

15 Mechanical hazards

15.1 Hazards to exposed persons due to uncontrolled movement 5.16.1
15.2 Hazards due to break-up and/or ejection of parts not applicable
15.3 Hazards due to rolling over (deflection limiting volume; DVL) not applicable
15.4 Hazards due to falling objects not applicable
15.5 Inadequate means of access 5.10
15.6 Hazards caused due to towing, coupling, connecting, transmission etc.
not applicable
15.7 Hazards due to batteries, fire, emissions, etc. 5.21.3, 5.21.4

HAZARDS DUE TO LIFTING OPERATION

16.1 Lack of stability 5.7
16.2 Derailment of machinery 5.16.4

Table 1 — List of hazards *(continued)*

Hazards Corresponding Requirement

16.3 Loss of mechanical strength of machinery and lifting accessories
5.7.5
16.4 Hazards caused by uncontrolled movement 5.8.1, 5.8.2, 5.4.5
16.5 Hazards due to falling loads 5.9.3, 5.9.5, 5.13, 7.3.1

17 Inadequate view of trajectories of the moving parts 5.4.3

18 Hazards caused by lighting not applicable

19 Hazards due to loading/overloading 5.8.4.2, 5.8.5.3

5 Safety requirements and/or measures

5.1 General

Machinery shall comply with the safety requirements and/or protective measures of this clause. In addition,
the machine shall be designed according to the principles of EN ISO 12100 (all parts) for relevant but not
significant hazards, which are not dealt with by this document.

5.2 Preventing unauthorised operation

Vehicle lifts shall be equipped with an accessible and fixed device that prevents unauthorized use after taking
the lift out of operation (refer to Annex B (informative)).

5.3 Control devices

5.3.1 Hold-to-run control

Control devices shall be of the hold-to-run type and shall fulfil the conditions of performance level c of
EN ISO 13849-1:2008. The stop-function shall comply with category 0 of 9.2.2 of EN 60204-1:2006.

5.3.2 Grouped control devices

If the control devices for more than one vehicle lift are grouped together in one position each control device
shall be clearly marked to show which vehicle lift it controls.

5.3.3 Logical operation

The control devices shall be designed so that the movement of the control and its location are consistent with
its effect (refer to Annex B (informative)).

5.3.4 Marking

The direction of the movement of the lifting element shall be permanently marked (refer to Annex B (informative)). The marks shall be suitable symbols or text and can be located on the control devices themselves or directly adjacent to them.

5.3.5 Inadvertent operation

Control devices shall be protected from unintentional operation (refer to Annex B (informative)).

5.4 Control positions

5.4.1 Layout

Control devices shall be designed and arranged so that they are within easy reach of a standing operator, and
so that the operator is not jeopardised by the load or the motion of the lift or of parts of the lift.
Where it is possible to control the lift from more than one control station, there shall be measures to enable
only one control stations at one time.
Remote control (wireless or wired) shall only be used if there exists an additional release switch at the vehicle
lift which has to be pushed when using the remote control. This additional switch shall be located so that the
person pushing it has a direct view to the load to be lifted/lowered.

The additional release switch is not necessary if the remote control system will only operate within a defined
standing area which gives the operator a direct view to the load to be lifted/lowered (e.g. short cable, infrared
control system).
Wireless control systems shall conform to Annex F (normative).

5.4.2 Visibility

The control position to operate the vehicle lift shall be designed and arranged, so that the operator can watch
the load carrying device and the load whilst in motion, as well as the space under the load carrying device and
the load. This applies to the operation of both multiple and single lifting devices.
If the vehicle lift is intended to be used so that the hazardous area cannot be completely viewed from the
operating position (the use of tools like mirrors or cameras/monitors is acceptable), e.g. vehicle lifts for railbound
vehicles, one or more additional release switch(es) approving the commands for the lifting movements
(on the side of the lifting system positioned across from the control position) are required.
NOTE This needs negotiation between user and manufacturer respectively supplier of the vehicle lift.
In addition if the vehicle lift is mobile the operator shall be able to observe the space especially in moving
direction of the vehicle lift.

5.4.3 Controlling several load carrying devices

If the load carrying devices of a vehicle lift are intended to be moved independently, a selection control shall
be provided that enables:
a) the independent movement of each load carrying device; and
b) movements of all load carrying devices together.
Other combinations of movements of the load carrying devices may also be incorporated and selected by the
selection control.
The non-selected load carrying devices shall be prevented from operating.

5.4.4 Emergency stop device

At a column lift for rail-bound vehicles, each column shall be equipped with an emergency stopping device
which fulfils the requirements of EN ISO 13850:2008 and stops the movements of all columns. The emergency stop device shall comply with performance level d of EN ISO 13849-1:2008.
The main switch can act as an emergency stop (refer to 5.3.3 and 10.7.4 of EN 60204-1:2006).

Activation of any of the emergency stops shall stop the motion of all the lifting devices. The stop-function shall
comply with category 0 of 9.2.2 of EN 60204-1:2006.

5.4.5 Stopping device

Each control position shall be equipped with a device to stop all movements of the vehicle lift. This device
shall have priority over the start controls and be able to stop the movements also in case of one failure as
mentioned in EN ISO 13849-2:2008.

5.5 Duplicated drive systems

Drive systems which are both motor driven and manually driven shall be designed in such a way that neither

drive can put the other drive into motion.

5.6 Speeds

5.6.1 Lifting and lowering speed

The speed for lifting and lowering shall not exceed 0,015 m/s for vehicle lifts for rail-bound vehicles (trains,
trams, etc.) and 0,15 m/s for other vehicle lifts.

5.6.2 Tilting speed

The speed of tilting, measured at the part of the load carrying device which is furthest away from the turning
centre, shall not exceed 0,1 m/s.

5.7 Structural design of the supporting structure

5.7.1 General

The design of vehicle lifts in relation to materials, construction and equipment shall be such that a satisfactory
level of safety is achieved under all operating conditions including the failure situations described in this
standard. This shall be demonstrated by calculation. Use of the permissible stress method is allowable.
The stress, resulting from the most unfavourable load distribution, shall be calculated for each load bearing
part. For permissible stresses refer to Annex A (informative). The values of Annex A are given under the
condition of 22 000 load cycles at rated load. If this value is exceeded, fatigue calculation shall be performed
for structure and mechanism. In case of exceptional situation the yield stress divided by a safety factor of 1,1
is acceptable.
Wheel support vehicle lifts for road vehicles shall be designed in such a way that during normal operation the
maximum inclination of the platform in its longitudinal axes is limited to 1°.

5.7.2 Loads and forces

5.7.2.1 Regular loads

a) Structural loads

The masses of components of the vehicle lift produce the structural loads.
1) Loads due to components which are not moving are considered to be static structural loads.
2) Loads due to moving components are considered to be dynamic structural loads.

b) Rated load

c) Dynamic forces

Dynamic forces are due to working movements such as raising, lowering and tipping in service. These
shall be taken into account by multiplying the moved structural loads and the payload by the dynamic factor φ, which shall be calculated in relation to the nominal speed v in metres per second. An alternative
to this is to take φ equals to 1,151 since the factor 0,34v is of the order 0,051 maximum.

$$\varphi = 1{,}1 + 0{,}34v$$

d) Manual forces

Manual force is produced by operators. This force shall be taken as 1 000 N acting horizontally at the

height of the supporting point. For motor bike lifts this force shall be 10 % of the rated load, but not less
than 300 N.

e) Effects of accessories

Effects of accessories for the vehicle lift, e.g. jacking beams, of a type approved by the manufacturer for
use on that lift.

f) Effects of inclination

Influence of permissible inclination.
Manual forces and dynamic forces do not act simultaneously and shall not be combined. Manual forces and
static forces shall be combined.

5.7.2.2 Occasional loads – In-service wind

If the vehicle lift is designed for outside use, the influence of wind forces in the wheel base direction shall be
included in the stress calculation (see also 5.7.3) and overturning calculation (see also 5.7.6).
The maximum pressure of in-service wind is 125 N/m2, which is related to a wind speed of 14 m/s (50,4 km/h).
The wind forces acting on the normative vehicle (refer to Table 4) shall be derived from Table 2.

Table 2 — Wind forces and stabilising effects

Rated load t	Wind force *Fw* kN	Stabilising weight effect [kN] and exposed surface [m2]		Axle wind force ratio in service out-ofservice	
				F_1/F_W	F_2/F_W F_3/F_W
a) *P* δ 2,5	0,75	3	6	0,40	0,60 /
b) 2,5 < *P* δ 3,5	1	4	8	0,40	0,60 /
c) 3,5 < *P* δ 7,5	1,875	7,5	15	0,33	0,66 /
d) 7,5 < *P* δ 20	2,25	9	18	0,33	0,66 /
e) 20 < *P* δ 30	2,625	10,5	21	0,33	0,66 /
f) 30 < *P* δ 40	3	12	24	0,45	0,55 /
g) *P* δ 25	5,25	21	42	0,25	0,30 0,45
h) *P* δ 40	4,875	19,5	39	0,20	0,30 0,50
i) 40 < *P* δ 52	5,25	21	42	0,20	0,30 0,50
j) *P* δ 40	4,125	16,5	33	0,17	0,33 /
k) 40 < *P* δ 52	4,875	19,5	39	0,17	0,33 /
l) *P* δ 45	4,875	19,5	39	0,20	0,40 0,40

5.7.2.3 Exceptional loads

a) Out-of-service wind

If the vehicle lift is designed for outside use the influence of wind forces in the wheel base direction shall

be included in the stress calculation (see also 5.7.3).
The maximum pressure of out-of-service wind is 500 N/m2, which is related to a wind speed of 28 m/s.
The wind forces acting on the normative vehicle (refer to Table 4) shall be derived from Table 2.
It is assumed that in any case the operator lowers the raised vehicle in the nearest position to the ground
level at the end of his working time. A corresponding requirement shall be written in the operation instructions if the vehicle lift is designed for outside use.
For the overturning stability calculation a stabilising weight effect of 1 kN for each square metre of exposed vehicle surface to the wind can be considered as stabilising moment (refer to Table 2).

b) Action

1) of the catching device; or
2) of the re-raising prevention device.

c) Test load for:

1) dynamic test (see 6.1.5.2);
2) static test (see 6.1.5.3).

5.7.3 Load combinations

The loads defined in 5.7.2 shall be combined and classified as indicated in Table 3.

Table 3 — Load combinations

Load	Clause	Load combination						
		A1	A2	B1	B2	C1	C2	C3
Regular loads	5.7.2.1							
Structural loads – static	a1	1	1	1	1	1	1	1
Structural loads – dynamic	a2	\ 1 \		1	1	1		
Rated load	b	\ 1 \		1	1	1		
Manual forces	d	-	1	-	1	-	-	-
Effect of accessories	e	\ 1 \		1	1	1		
Effect of inclination	f	\ 1 \		1	1	1		
Occasional loads - In-service wind	5.7.2.2	-	-	1	1	-	-	-
Exceptional loads	5.7.2.3							
Out-of-service wind	a	-	-	-	-	1	-	-
Action of the catching device	b1	-	-	-	-	-	1	-
Action of the re-raising prevention device	b2	-	-	-	-	-	-	1

Load combination A1: Normal operation (raising/lowering) without wind or special forces
Load combination A2: Normal operation (service/repair work) without wind or special forces
Load combination B1: Normal operation (raising/lowering) with wind force
Load combination B2: Normal operation (service/repair work) with wind force
Load combination C1: Vehicle lift out of service with wind force
Load combination C2: Action of the catching device
Load combination C3: Action of the re-raising prevention device
\: Multiplication factor according to 5.7.2.1.

5.7.4 Load distribution

5.7.4.1 General

The following requirements shall be fulfilled if no special data are specified by the customer. The rated load
shall be distributed on the four corners of a rectangle with the width equating to wheel track and the length to
wheel base.

5.7.4.2 Wheel support vehicle lift for road vehicles

The rated load shall be distributed according to normative vehicle dimensions as shown in Table 4.

When carrying out structural design in accordance with the data given in Table 4 consideration shall be given
in each case to normative vehicles both less than and equal to the rated load to ensure that the most adverse
loading situations are considered.
For structural design purposes vehicle positioning on load carrying devices shall be considered in both
directions.
The vehicle track symmetry axis and the wheel supports symmetry axis are coincidental.
For all normative vehicles with more than two axles, the 2- or 3-axle combinations shall be considered as a
single "virtual" axle.
The minimum distance *X* between the nearest vehicle axle and the wheel support end depends on the type of
normative vehicle (dimension, single-, double-, triple-axle) (refer to Table 4).
When calculating for tracks, the plate stresses caused by supporting the loads shall be taken into account
assuming that the load is uniformly distributed on a square or circular area at a pressure of 50 N/cm². In the
case of a virtual axle the force to be considered for calculating plate stresses shall be equally distributed on
each axle. Plate stresses need not be considered if the plain area between any two flanges or supporting
sections is not considered when calculating the supporting cross section.
Structural design shall consider the vehicle driving on and off wheel supports.

Table 4 — Normative vehicle

Item Rated load
t
Type of
vehicle
No. of
axles Normative vehicle
Wheel
track
WT
m
Wheel base
m **Axle load ratios Min. distance**
m
WB_1 WB_2 WB_3 AL_1/P AL_2/P AL_3/P X_1 X_2
a $P \leq 2,5$ Passenger
cars 2
1,5 2,5 - - 0,40 0,60 - 0,3 0,3
b $2,5 < P \leq 3,5$ Commercial

light truck 2
1,6 3 - - 0,40 0,60 - 0,3 0,3
c 3,5 < *P* ≤ 7,5
Commercial
medium
trucks
2 1,7 3 - - 0,33 0,66 - 0,3 0,3
d 7,5 < *P* ≤ 20 Lorries 2/3
1,8 3,5 - - 0,33 0,66 - 0,5 0,5
e 20 < *P* ≤ 30 Lorries 3
1,9 4 - - 0,33 0,66 - 0,5 1
f 30 < *P* ≤ 40 Lorries 4
1,9 4,5 - - 0,45 0,55 - 1 1
g *P* ≤ 25 Articulated
busses 3
1,8 5,5 6,5 - 0,25 0,30 0,45 0,5 0,5
h *P* ≤ 40 Articulated
lorries 4
1,9 3,5 7 - 0,20 0,30 0,50 0,5 1

Table 4 *(continued)*

Item Rated load
t
Type of
vehicle
No. of
axles Normative vehicle
Wheel
track
WT
m
Wheel base
m **Axle load ratios Min. distance**
m
***WB*1 *WB*2 *WB*3 *AL*1/*P* *AL*2/*P* *AL*3/*P* *X*1 *X*2**
i 40 < *P* ≤ 52 Articulated
lorries ≥ 5
1,9 3,5 7 - 0,20 0,30 0,50 0,5 1,6
j *P* ≤ 40 Lorries with
trailer 4
1,9 3,5 3 3,5 0,17 0,33 - 0,5 0,5
k 40 < *P* ≤ 52 Lorries with
trailer ≥ 5
1,9 4, 3 4 0,17 0,33 - 0,5 1
l *P* ≤ 45 Lorries with
trailer ≥ 5
1,9 4 5 - 0,20 0,40 0,40 0,5 1

5.7.4.3 Chassis supporting vehicle lift for road vehicles

The load rectangle wheel track symmetry axis and the lift wheel track symmetry axis are coincidental.
Pick-up plates and their shafts shall be designed to suit the load acting at a point half way between the centre
and the outside edge of the pad.

a) Rated load ≤ 3,5 t

For rated loads ≤ 3,5 t the load ratios between the front and rear load carrying points shall be (in both directions):

2 : 3 and 3 : 2 (maximum load one pick-up point 3/10 of *P*)

On platform lifts the rated load shall be distributed on the four corners of a rectangle with the dimensions
of:
- 100 cm (width) × 140 cm (length); and
- 170 cm (width) × 140 cm (length)

at the maximum length of the platform and at the worst condition (with the maximum load at the corner of
the platform or platform extension).
On vehicle lifts with carrying arms the rated load shall be distributed on the four corners of a rectangle
with the dimensions of 100 cm (width) with the maximum load at the maximum length of the longest arm
and the short arm in the position which gives the worst condition.

b) Rated load > 3,5 t

For rated loads > 3,5 t the load ratios between the front and rear load carrying points shall be (in both
directions):

1 : 3 and 3 : 1 (maximum load one pick-up point 3/8 *P*)

On platform lifts the rated load shall be distributed on the four corners of a rectangular with the dimensions of:
- 100 cm (width) × 180 cm (length); and
- 170 cm (width) × 180 cm (length)

at the maximum length of the platform and at the worst condition (with the maximum load at the corner of
the platform or platform extension).
On vehicle lifts with carrying arms the rated load shall be distributed on the four corners of a rectangle
with the dimensions of 100 cm (width) with the maximum load at the maximum length of the longest arm
and the short arm in the position which gives the worst condition.

5.7.4.4 Special vehicle lifts (lifts for forklift trucks, dumpers, rail-bound vehicles, etc.)

Where the prescriptions of 5.7.4.2 and 5.7.4.3 cannot be applied:
a) the load distribution shall be in accordance with the axle loadings of the vehicles which are to be lifted. If
the lift is intended for use with different models of vehicle, the distribution shall suit the most unfavourable
model;

b) all lifts which are designed for load distributions other than those in 5.7.4.2 and 5.7.4.3 shall be equipped
with clearly understood load distribution plates and load plates respectively (on mobile column lifts) of
sufficient size and placed in conspicuous locations.

5.7.5 Lifting elements

5.7.5.1 Catching devices and mechanical re-raising prevention devices

In case of response of catching devices or re-raising prevention devices no permanent deformations shall
occur in any part required for continued normal operation.
If permanent deformation occurs in a safety device, exact instructions shall be given in the operation manual
with regard to the measures to be taken (e.g. replacement of the part, removal of burrs).

5.7.5.2 Rope drives

Steel wire ropes for rope drives shall comprise a minimum of 114 single wires. The nominal tensile grade of
each wire shall be at least 1 570 N/mm$_2$ but not exceed 1 960 N/mm$_2$.
The tensile grade of terminations shall be a minimum of 80 % of that of the rope.
For the terminations of wire ropes the following shall be used:

- splices;
- aluminium press ferrules;
- non-ageing steel press ferrules;
- wedge socket anchorages.

The minimum breaking force of the wire ropes shall be shown on a certificate.
Wire rope, drum and pulley diameters shall be calculated according to ISO 4308-1:2003 using the classification of mechanism M5 or higher. Ropes used for synchronization shall be calculated using the
classification of mechanism M3 or higher.
As an alternative wire rope, drum and pulley diameters can be calculated according to Annex C (normative).

5.7.5.3 Chain drives

The minimum breaking load of chains shall be at least four times the maximum possible static load, with the
rated load in the most unfavourable position. Proof of minimum braking load shall be provided in the form of a
manufacturer's certificate.
Chain wheels and sprockets with undercut teeth shall not be used.
The tensile strength of terminations shall be a minimum of 80 % of that of the chain.

5.7.5.4 Hydraulic and pneumatic drives

Hydraulic and pneumatic cylinders, pipes and their connections which may be subjected to the maximum
pressure permitted by the pressure relief valve shall be designed to withstand at least:

- two times this pressure in hydraulic drives;
- three times this pressure in pneumatic drives

without permanent deformation.
Hoses, air bags and bellows shall be dimensioned in order to withstand a bursting pressure equal to at least
three times the maximum pressure permitted by the pressure relief valve.

5.7.5.5 Screw-drives

The lead screw mechanism shall be designed to prevent separation of the load supporting device from the
mechanism during normal use.
Each spindle shall be fitted with a load bearing nut and an unloaded safety nut or other constantly active
safety device. The safety nut shall only be loaded if the load bearing nut fails.

Screw-drives using recirculating ball systems may use a catching device according to 5.13.1 instead of safety
nuts.
Lead screws shall be fitted with devices at both ends to prevent the load bearing and safety nuts from leaving
the threaded portion of the lead screws.
The lead screw material shall have a higher abrasion resistance than the load bearing nut material. For drives
using recirculating ball systems other criteria for the materials involved are valid.

5.7.5.6 Mechanical connections of several lifting elements

If a mechanical synchronization device is used to control the height of lifting elements, this device, including
the mechanical elements, shall be able to withstand the worst load differences that can or will be possible
between the lifting elements including failure of lifting elements, hydraulic leakage, etc.

5.7.6 Proof of stability against overturning

Lifts which are not anchored to the ground are considered stable if the stabilising moments, M_s are greater
than the tilting moments, M_t multiplied by a safety factor. If the vehicle weight acts to stabilise the lift then a
stabilising weight can be considered in the calculation. The stabilising weight effect of each type of normative
vehicle is shown in Table 2. All load combinations enumerated in 5.7.3 shall be investigated with forces acting
in their most unfavourable direction. The following conditions shall be fulfilled:

- *Case A*: $1{,}3 \cdot M_t \leq M_s$
- *Case B* : $1{,}2 \cdot M_t \leq M_s$
- *CaseC* : $1{,}1 \cdot M_t \leq M_s$

NOTE The same criteria apply by using fixing bolts to fix the vehicle lift on the floor.

5.8 Driving machinery

5.8.1 Preventing inadvertent motion

Vehicle lifts shall be provided with an automatic device which prevents inadvertent motion of the load carrying
device and which operates above the first 500 mm of vertical travel of the load carrying device from the initial
position (refer to Annex B (informative)). Vehicle lifts designed to be used over pits or as wheel free systems
shall fulfil this requirement throughout the travel of the load carrying device.
Where brakes are used to fulfil this requirement, compression springs shall provide the brake action (see 5.18.5). The springs shall be adequately supported and shall not be stressed in excess of 80 % of the
torsional elastic limit of the material.

Band brakes shall not be used.
Brake linings shall be of incombustible material (excluding asbestos) and shall be fixed such that normal wear
does not weaken the fixings.
Brakes shall be provided with means of adjustment.
Brake blocks and linings shall be protected against ingress of lubricants, water, dust or other contaminants.

5.8.2 Holding devices

Where lifts are designed for people to stand under the vehicle and load carrying devices, the lifting elements
operating those carrying devices, or the carrying devices themselves, shall be held automatically in their
inoperative position by self-locking means (refer to Annex B (informative)).

5.8.3 Additional requirements for mechanical drives

5.8.3.1 Derailment protection

Pulleys and wheels for ropes and chains shall be provided with derailment protection. This shall be designed
such that the rope or chain cannot pass between the derailment protection and the pulley or wheel.

5.8.3.2 Safety at nip points

Safeguards shall be provided to prevent access to wire rope and chain nip points.
When it is foreseen (e.g. maintenance) that fixed guards will be removed regularly then the fastenings shall
remain attached to the guards or to the vehicle lift.

5.8.3.3 Tension regulation

If more than one rope or chain are acting at one point it shall be possible to regulate their tension.

5.8.4 Additional requirements for hydraulic drives

5.8.4.1 General

The requirements of EN 982:1996+A1:2008 shall be fulfilled.

5.8.4.2 Pressure relief valve

The hydraulic system shall be provided with a pressure relief valve. If different maximum pressures are used
in separate circuits of the hydraulic system, then one pressure relief valve shall be provided for each circuit.
The pressure relief valve shall be the first valve in any circuit. The adjustment of the pressure relief valve shall
only be possible by means of tools and protection shall be provided which prevents unauthorized adjustment.
Pressure relief valves shall be adjusted to act at a pressure which is not more than 10 % above that produced
when operating with the rated load.

5.8.4.3 Bleeding

It shall be possible to bleed the hydraulic system.

5.8.4.4 Connection for pressure gauge

In all hydraulic systems there shall be a connection for a pressure gauge at an accessible location.

5.8.4.5 Filter

In all hydraulic systems there shall be a device that filters the hydraulic fluid. In fluid tanks there shall be a
device that filters the incoming air.

5.8.4.6 Fluid level control

Hydraulic tanks shall be provided with means of indicating the actual level and the minimum permissible fluid
level.

5.8.4.7 Size of the fluid tank

Fluid tanks shall be of sufficient size such that their capacity exceeds the displaced volume of the related
lifting system by at least 10 %.

NOTE "Lifting system" means all the hydraulic cylinders.

5.8.4.8 Gas loaded accumulator

If a gas loaded accumulator creates the necessary pressure for the hydraulic bearing device, the motion shall
automatically stop as soon as the allowable minimum liquid level in the tank is reached.

5.8.5 Additional requirements for pneumatic drives

5.8.5.1 Introduction

The requirements of EN 983:1996+A1:2008 shall be fulfilled.

5.8.5.2 General

If the vertical travel of the load carrying device is greater than 500 mm then the vehicle lift shall be fitted with
an automatic mechanical interlocking and holding device. Note this is in order to restrict the hazard of
unintended motion of the load carrying device (refer to Annex B (informative)). Vehicle lifts designed to be
used over pits or as a wheel free system shall fulfil this requirement throughout the travel of the load carrying
device.

5.8.5.3 Pressure relief valve

The pneumatic system shall be provided with a pressure relief valve. The non return valve shall be located
between the pressure relief valve and the cylinder.
If different maximum pressures are used in separate circuits of the pneumatic system, then one pressure relief
valve shall be provided for each circuit. The pressure relief valve shall be the first valve in any circuit. The
adjustment of the pressure relief valve shall only be possible by means of tools and protection shall be
provided which prevents unauthorised adjustment.

5.8.5.4 Pressure reduction

If the pressure created by the pressure generator is greater than the adjusted pressure of the pressure relief
valve, a device shall be installed that will automatically reduce the generated pressure (refer to Annex B
(informative)).

5.8.5.5 Hot working

Pneumatic lifts with air bags and bellows as lifting element which are intended to be used in connection with
hot works (welding, grinding, etc.) shall have protection against damage, for example by covering the bellow.

5.8.5.6 Use in low temperatures

Vehicle lifts which are intended to be used at a temperature below + 10 °C shall be designed so that ice
formation in the pneumatic system is prevented, for example by the metering of spirits.

5.8.5.7 Moisture reduction

The pneumatic system shall be equipped with a moisture reduction device.

5.9 Load carrying devices

5.9.1 Unintended motion of the load carrying device

Load carrying devices shall be designed in order to prevent swinging, inadvertent tilting, rotating or shifting.

5.9.2 Vehicle pick-up-plates

Pick-up-plates and pad extensions shall engage with the basic carrying member so as to prevent it from
overturning when subject to a horizontal force of H = 1 000 N, applied in the most unfavourable direction,
when the lift is loaded with the rated load. The centre of gravity of the vertical load shall be considered to act
on the pick-up-plate at 50 % eccentricity and the plate adjusted to the maximum height (see Figures 3 and 4).
In the case of pad extensions only one shall be used at each lifting point.

Key

1 pick-up plate
2 load carrying part
3 pin
4 vertical load
H horizontal force
r radius of the pick-up plate

Figure 3 — Pick-up plates

Vertically adjustable pick-up plates with threaded spindles shall be self-braking and shall be prevented from
unscrewing (see Figure 4).

Key

1 pick-up plate
2 load carrying part
3 vertical load
H horizontal force
r radius of the pick-up plate

Figure 4 — Adjustable pick-up plates

Key

1 1/3 of the rated load
2 pad extension
3 load carrying part
H horizontal force

Figure 5 — Pad extension

5.9.3 Vehicle pick-up pads

If pick-up pads are used on the carrying device of the lift, the following requirements shall be observed:
a) Pick-up pads shall be prevented from sliding, for example with an interlocking or friction surface between
the pick-up pad and the carrying device of the lift. This system shall be capable of withstanding a horizontal force of H = 1 000 N, applied in the most unfavourable position and condition (e.g. oil between
pad and carrying device), and with the lift loaded with 1/3 of the rated load, without giving rise to movement of the pad.

b) The pick-up pads shall be conical or cubic in order to assure a safe and clear use. The maximum ratio
between height of the pad and the diameter of the largest circle which could be inscribed in the base of
the pick-up pad shall not exceed 1:1.

5.9.4 Securing devices on vehicle lifts where the load carrying devices can tilt

Where vehicle lifts allow tilting of the load carrying device, a mechanical securing device shall be provided
which positively locks the vehicle to the load carrying device.

5.9.5 Locking systems of carrying arms

Carrying arms shall be equipped with automatic mechanical locking systems that prevent the arms from
swinging inadvertently and which operate, regardless of load, above the first 300 mm of vertical travel. Vehicle
lifts designed to be used over pits or as a wheel free system shall fulfil this requirement throughout the travel
of the load carrying device.
If this locking system operates in discrete steps, the step increment at the end of a fully extended arm shall
not be greater than the diameter of the pick-up plate.
It shall not be possible to fix the arm locks in a disengaged condition above 300 mm of travel.
Arm locking systems shall be designed to resist a force of 4,5 % of the capacity of the lift without permanent
deformation, or to resist a force of 6,75 % of the capacity without breakage. The forces used however shall not
be less than 1 500 N and 2 250 N respectively. Forces are assumed to act horizontally at the load carrying
points, and in the most unfavourable direction, with the arms fully extended.

5.9.6 Roll-off safety device

Each track shall have end stops at both ends to prevent vehicles from rolling off. The stop shall automatically
raise into position after a vertical travel of the tracks of 0,75 m, or they shall be securely fixed in position. The
height of stops shall be at least 0,1 m above the surface of the track.
Roll-of safety devices for rail vehicles shall have a minimum height of 25 mm above the track and shall
automatically come into operation after a vertical travel of the tracks of 0,1 m.
Each end stop shall be designed to resist a horizontal force of 20 % of the rated load, applied to the top,
without permanent deformation or to resist a force of 30 % of the rated load without breakage.

5.10 Additional requirements for lifts with balconies

Vehicle lifts with integrated accompanying or stationary elevated front or side balconies higher than 1 m above
the ground shall be equipped with means to prevent people falling from the balconies.
The means of prevention shall, as a minimum, consist of rigid guard-rails at least 1,1 m high, rigid toe guards
at least 0,15 m high and rigid intermediate guard-rails not further than 0,5 m from either guard-rail or toe
guards.
Movable parts of the means of prevention shall be securable against unintended motion during their operation.
Swinging or tilting parts shall be inward opening.
When it is foreseen (e.g. maintenance) that the fixed guard rails will be removed regularly then the fastenings
shall remain attached to the guards or to the machine.
Protection devices are not necessary in the following cases:

a) around the normal openings required for working under the vehicle;

b) at stationary balconies on the sides facing the carrying device.
The surface of elevated front and/or side balconies shall be non-slip. Holes, spaces or piercings in the balcony
surface shall be no larger than would allow a sphere of 0,02 m diameter to pass through.
For the prevention of trapping between moving parts refer to 5.17.3.

5.11 Limiting the travel of the load carrying device

Before the load carrying device reaches its extreme end positions its motion shall be stopped.
Hydraulic or pneumatic cylinders which directly carry the load carrying device shall have a mechanical stop or
an overflow which limits the lifting height.
Vehicle lifts using hydraulic or pneumatic cylinders in which the load carrier is completely or partly carried by
ropes or chains without incorporating a mechanical stop at the cylinder shall limit the lifting height by switching
off the corresponding control circuit.
For mechanically driven vehicle lifts devices shall be provided which switch off the corresponding control
circuit at the normal limits of the raising and lowering movement.
Mechanically driven vehicle lifts shall also be provided with mechanical stops or safety switches at both
extremes of travel to give additional safety in the event of failure of the normal limit devices. Failure of the
upper normal limit device and/or actuation of a safety switch shall result in the lowering of the load being
permitted but subsequent re-raising from the initial position prevented.

5.12 Unintended blocking of the load carrying device

To prevent unacceptable slack or free play, vehicle lifts in which the lowering motion of a load carrying device
is achieved by gravitational force and not directly driven downwards by permanently fixing to the drive force,
shall be equipped such that the drive power is cut, and the motion of all the carrying devices is stopped.
Motion in the opposite direction shall still be possible (refer to Annex B (informative)).

5.13 Safety against rupture of mechanical bearing devices

5.13.1 Safety catch

Vehicle lifts in which the load carrying devices are held by ropes or chains, and vehicle lifts with mechanical
lifting elements shall be designed to prevent the load carrying devices from lowering more than 100 mm in
case of rupture of rope, chain, carrying nut or gear. This shall be operational at any stationary position after a
vertical travel of the load carrying device of 500 mm as well as during the lifting and lowering cycles. A safety
device shall be operated in this event which automatically stops the motion. Vehicle lifts designed to be used
over pits or as a wheel free system shall fulfil this requirement throughout the travel of the load carrying device
(refer to Annex B (informative)).
The safety catch shall be independent of the drive system and not be dependent on energising or maintaining

an electrical or other auxiliary circuit.

5.13.2 Unloaded accompanying bearing devices

As an alternative to a safety catch according to 5.13.1 ropes, chains, carrying nuts or gears which accompany
the normal lifting elements and which are unloaded during normal operation can be used. In the case of failure
of the normal lifting element it can be possible to lower the load, but restarting the lifting operation from the
initial position shall be prevented.

5.14 Safety against leakage

5.14.1 Limiting the lowering speed

Vehicle lifts with hydraulic or pneumatic drives shall be designed to prevent the load carrying device from
lowering faster than 1,5 times the normal lowering speed in the case of leakage in the line.

5.14.2 Protection against leakage

Vehicle lifts shall be designed to prevent the load carrying device from moving more than 100 mm from any
position in case of leakage after a vertical travel of the load carrying device of 500 mm. Vehicle lifts designed
to be used over pits or as a wheel free system shall fulfil this requirement throughout the travel of the load
carrying device (refer to Annex B (informative)). Depending on the type of vehicle lift the solutions described in
Annex E (normative) to fulfil this requirement are accepted.

Any safety device used to achieve this may be released in order to lift or lower the carrying device, but shall
automatically resume its function after an intentional stop.

If two or more mechanically connected cylinders are carrying the same load and are independently equipped
with non-return valves, each cylinder shall be designed to carry the total load without permanent deformation.

5.15 Additional requirements for lifts with several drives or lifting elements

If vehicle lifts are designed to carry the load on several drives or lifting elements, it shall be assured that:

a) the separate lifting platforms respectively lifting elements are not overloaded when carrying the intended
load;

NOTE 1 When placing the load, load differences between separate lifting units or lifting elements may occur due to
unsymmetries of the load.

b) carried loads cannot roll, slide, tilt or rotate;

c) unintentional desynchronisation is limited within the following constraints (see 5.4.3 and Annex B (informative)):

1) a difference of 50 mm or 1° of tilt in case the difference is more than 50 mm;

2) an additional 100 mm difference in case of blockage of the lifted load, rupture of the driving or control
unit, leakage in the hydraulic or pneumatic line, of rupture of ropes, chains, nuts or gears;

3) with vehicles having a high torsional rigidity (e.g. rail vehicles) overloading of the lifting system can already occur within the limits mentioned under 1) and 2). Measures shall be taken to prevent overload including the additional desynchronisation caused by the function of safety devices (e.g. overdimensioning or load-limiting device). The correct placing of the load shall be monitored during

start up as well as during lifting and lowering (load sensing and/or levelling device).
NOTE 2 For vehicle lifts mentioned in 3) special attention (negotiation between user and manufacturer) should be
given to the maximum values described in 1) and 2).
The safety concept of the system (e.g. electrical control system of lifting platforms) shall, as a general, comply
with performance level c of EN ISO 13849-1:2008.
Safety related parts of control systems for vehicle lifts mentioned under c) shall comply with performance
level d of EN ISO 13849-1:2008.

In case of failure measures shall be provided to ensure restoration of orderly conditions. The correct procedure in case of a stop due to an "out of limits" synchronisation system shall be provided within the
complete operation instructions.

5.16 Additional requirements for movable and mobile lifts

5.16.1 Safety against unintended motion

It shall be possible to prevent mobile or movable vehicle lifts from moving inadvertently on level floors and
those which slope within the limits stated by the lift manufacturer (refer to Annex B (informative)).
Brakes used to fulfil this requirement shall be dimensioned such that they will prevent spontaneous movement
of a vehicle lift at rest and loaded with the rated load, on a slope 2° greater than stated as accepta ble by the
manufacturer.

5.16.2 Service brakes for vehicle lifts using powered mobility

Vehicle lifts which use powered mobility shall be equipped with automatic brakes.
The brakes shall be dimensioned such that they can stop an unloaded vehicle lift running at the maximum
speed stated by the manufacturer and on a slope 2° greater than stated as acceptable by the manufacturer.

5.16.3 Devices for moving manually mobile lifts

Suitable hand grips shall be provided on manually mobile lifts where the frame does not afford adequate
gripping. Grips shall be designed to prevent hand injury and shall be positioned so that their use does not
produce a hazard of foot trapping around the frame or wheels of the vehicle lift during movement of the
vehicle lift.

5.16.4 Derailment protection

If a vehicle lift is moved on rails, derailment shall be prevented.

5.16.5 Forces

The manual forces at an ambient temperature of (20 ± 5) °C shall not exceed 400 N to start the movement
and 300 N to sustain the movement on a flat level floor.

5.17 Protection against pinching and shearing

5.17.1 General

Pinching and shearing points shall be made safe by means of sufficient distance between the moving parts or
between the moving and stationary parts. If this is not possible other means shall be used so that neither the

operator nor bystanders are jeopardised.
Persons standing next to a lift are considered protected from pinching and shearing points between the
carrying device and the ground if coverage is afforded by the vehicle being lifted.

5.17.2 Safety distances

As a minimum the following parts of the human body shall be safeguarded by these minimum distances:

- width of fingers: 25 mm;
- height of feet: 120 mm.

The pinching and shearing points for feet are considered as avoided if a minimum free space for feet is
maintained in accordance with Figure 6.
Dimensions in millimetres

Figure 6 — Clearance for feet

Exceptions are permitted for drive on ramps which are mounted in such a way that the vertical squeezing
forces are restricted to not more than 250 N.

5.17.3 Other safety measures

For places where the specified distances cannot be observed, devices such as covers or rails shall be used to
prevent access to the dangerous areas or other devices shall be used which stop the movement of the lift if an
object or part of the body is placed in its path. In all cases these devices shall not give rise to any additional
hazards.
Covers or rails may be constructed from rigid or flexible materials. Rigid materials shall be dimensioned so as
to withstand any load to which they are likely to be subjected without permanent deformation. Flexible
materials shall be robust enough not to be damaged during their use.
Devices which stop the movement of the lift (e.g. pressure sensitive edges/bars according to EN 1760-2:2001+A1:2009) shall do so before a dangerous situation arises.
The requirement for protection of feet is also satisfied if, during the lowering of the lift, the movement is
automatically halted at a distance of 120 mm before the dangerous position. The movement may then be
restarted by operation of an additional lowering control or by releasing and reactivating the normal lowering
control. This final portion of the travel shall be accompanied by an audible warning. In either case it shall not
be possible to override the stopping device such that the lift travels to its initial position without stopping.
For wheel free systems the requirement for protection against pinching and shearing is satisfied:

- if there exists a safety distance of at least 25 mm between the scissor arms when operating the controls
for lowering an acoustic signal is automatically activated which sounds during the whole lowering movement;
- if there exists no safety distance between the scissor arms when operating the controls for lowering an
acoustic signal is automatically activated two seconds before the movement starts and continues throughout the whole of the lowering movement.

When it is foreseen (e.g. maintenance) that the fixed guards will be removed regularly then the fastenings
shall remain attached to the guards or to the vehicle lift.

5.18 Safety devices

5.18.1 Introduction

Safety devices for vehicle lifts are emergency stop devices (see 5.4.4), devices to prevent inadvertent motion
(see 5.8.1), pressure relief valves (see 5.8.4.2 and 5.8.5.3), arm locking systems (see 5.9.5), roll-off safety
devices (see 5.9.6), safety catches (see 5.13.1), unloaded accompanying bearing devices (see 5.13.2), safety
means in the event of hose and pipe damage (see 5.14), means to prevent pinching and shearing (see
5.17.3), safety switches (see 5.18.4).

5.18.2 General

Safety devices shall be designed and arranged so that they are protected against unauthorised or inadvertent
adjustment or damage.

5.18.3 Function of safety devices

Mechanical safety devices shall operate by using mechanically interlocking parts and not rely on friction.

5.18.4 Safety switches

Safety switches shall fulfil the requirements of EN 60947-5-1:2004.
Safety switches in lifts are, for example, switches that will stop the drive in the event of inadvertent blocking of
the carrying devices, or switches in switch-off elements that protect pinching and shearing points. In this
instance only the current motion shall be stopped, and the reverse motion may be still obtainable.
Safety switches which control failure are, for example, emergency limit switches, wire rope, chain, nut, or gear
rupture switches, or levelling control switches. After being operated, those switches shall prevent normal
further operation of the lift (refer to Annex B (informative)).
Safety switches shall operate such that safety devices are activated by cutting off the power.

5.18.5 Springs in safety devices

Failure of a spring shall not make safety devices inoperative (refer to Annex B (informative)). Furthermore,
compression springs shall be guided to prevent them buckling or the ends becoming displaced during use.

5.19 Protection against damage

5.19.1 Wearing parts

It shall be possible to inspect wire ropes, chains and screws over their whole length without difficulty for
maintenance and examination. Thread wear on the lifting nut shall be measurable without difficulty, for
example, by careful measurement of the distance between the lifting nut and the unloaded safety nut. If
necessary, inspection holes shall be provided.

5.19.2 Lead screws

Lead screws in screw drives shall be protected from damage and dirt.

5.19.3 Installation of hoses, pipes and electrical equipment

Hoses, pipes and electrical equipment shall be installed such that they will not be damaged during the
movement of loads or part of the machinery.

5.20 Manually driven vehicle lifts

Control mechanisms of manually driven vehicle lifts shall be equipped in such a way that:
a) winding handles, levers or wheel cannot turn back under load more than 15 cm, measured at the greatest
radius of the control (reversal security). Reversal security shall not be necessary for hand-wheels if these
take the form of complete smooth disc wheels imperforate and without any other handles;
b) the direction of rotation of winding handles remains the same regardless of gearing; and
c) removable winding handles, levers, and hand wheels shall be secured against slipping and unintentional
removal from the drive shaft (refer to Annex B (informative)).
The driving force on the provided handle measured at the end of it at the rated load at an ambient temperature
of (20 ± 5) °C shall not exceed 400 N when driven according to the manufacturer's specification.

5.21 Electrical equipment

5.21.1 General

All parts of electrical equipment shall meet the requirements of the relevant CENELEC-Standards, especially
EN 60204-1:2006.

5.21.2 IP-code

The IP-code according to EN 60529:1991 shall be at least IP 54. Components in systems less than 48 V do
not need to meet this specification if disconnection or malfunction does not lead to an unsafe situation.

5.21.3 Means of disconnecting the power supply

Vehicle lifts with electrical drives shall be equipped with a device that allows the power supply to be disconnected (see EN 60204-1:2006). Deviating from 5.3.3 of EN 60204-1:2006 a switch with two Onpositions
which control the up and down movement can be used if it fulfils all other requirements on a main switch according to EN 60204-1:2006.

5.21.4 Batteries

Batteries shall be secured in position and be protected against external effects such as vibrations, water, high
pressure cleaning, etc.

5.22 Special requirements for vehicle lifts where it is permitted to stand under the load during lifting and lowering movement

5.22.1 Control devices

To avoid unintentional movements in case of one failure, the control circuits for lifting and lowering movement
as well as the emergency stop function shall comply with performance level d of EN ISO 13849-1:2008. All
relevant failures listed in EN ISO 13849-2:2008 shall be considered.

5.22.2 Control positions

Control positions shall be located in a way that persons standing under the vehicle are in a direct field of vision
of the operator at the control devices. A direct speech communication shall be possible. If necessary, an
additional control position shall be provided. If remote control is activated all other controls shall be deactivated.

If the vehicle lift is fitted with a remote control (wired or wireless) which can be used from a position under the
load a release switch at a fixed position outside of the hazardous area shall be provided. From the position of
the switch the operator shall have a direct view to the person under the load. The release switch shall be of
the hold-to-run type.

5.22.3 Lifting and lowering speed

The maximum speed for lifting and lowering shall not exceed 5 mm/s.

5.22.4 Safety against rupture or leakage of load bearing devices

Vehicle lifts shall be equipped with facilities preventing unintentional lowering of more the 20 mm in case of
rupture of ropes, chains, carrying nuts or gears or leakage in the hydraulic or pneumatic system. These
facilities shall be effective during lifting and lowering movement as well as at the standstill of the raised load.

5.22.5 Operation instructions

The operation procedure in case of a person is standing below moving loads shall be described precisely in
the operation instructions. At least two persons are required for this mode of operation (operator and worker
under the load).

6 Verification of the safety requirements and/or measures

6.1 General

6.1.1 Introduction

The tests given in this verification chapter shall be used to verify the compliance of vehicle lifts and their
components with this standard. These tests shall be carried out on at least a sample of each model type.

The test to ensure that the vehicle lift complies with this standard shall consist of:

a) design check (see 6.1.2);
b) manufacturing check (see 6.1.3);
c) visual verification (see 6.1.4);
d) practical tests (see 6.1.5).

The results of examinations and tests, either done by the manufacturer or by a competent body, and the name
and address of person(s) and firm making them shall be recorded in a signed report.

6.1.2 Design check

The design check shall verify that the vehicle lift is designed in accordance with this standard. It shall at least
be checked that:

a) drawings contain the main dimensions of the vehicle lift;

b) there is a description of the vehicle lift with necessary information about its capabilities;
c) there is information about the material and components used;
d) there are diagrams of the electrical, hydraulic and pneumatic circuits;

e) there are instructions covering installation, commissioning, operating, maintenance and dismantling.
The documents shall give all necessary information to enable:
f) the structural calculations to be checked;
g) the stability calculations to be checked.

6.1.3 Manufacturing check

The manufacturing check shall verify that:
a) the vehicle lift is manufactured in accordance with the checked documents, with special attention to safety
devices;
b) the test certificates are available for ropes, chains and hoses;
c) welding has been performed according to the drawings.

6.1.4 Visual verification

It shall be verified that:
a) all markings defined in 7.2, 7.3.2 and 7.4 are attached to the vehicle lift;
b) the vehicle lift is in accordance with all documentation provided by the manufacturer.

6.1.5 Practical tests

6.1.5.1 General

Practical tests shall be made to verify that:
a) the vehicle lift is stable;
b) the vehicle lift is structurally sound;
c) all functions work correctly and safely.

6.1.5.2 Overload dynamic test

The test load shall be 115 % of the rated load.
The load distribution shall be made in accordance with 5.7.4.
All movements with the test load shall be carried out at accelerations and decelerations appropriate with safe
control of the load. The intended movements shall be carried out with care taking into due account the least
favourable positions and when vibrations associated with preceding movements have subsided.
When, due to various combinations of load distributions of a vehicle lift, tests with different test loads are
necessary, all movements shall be carried out with all test loads except where the least favourable conditions
can be simulated by one performance test. During this test the vehicle lift shall be capable of stopping and
sustaining the test load(s).

6.1.5.3 Overload static test

The test load shall be 150 % of the rated load.

During this overload static test the vehicle lift shall be put into each position which creates maximum stress in

any load carrying part of the lift.
After removing the test load(s) the vehicle lift shall show no permanent deformation.

6.1.5.4 Functional tests

a) With rated load

Functional tests with rated load shall demonstrate that:
1) the vehicle lift can be operated smoothly for all motions at the rated speed;
2) the safety devices work correctly. This included the protection against leakage (see 5.14.2), which shall be tested with 40 % and 100 % of the rated load;
3) the levelling devices work within stipulated differences (see 5.15);
4) maximum permitted speeds are not exceeded.

b) Without load

Functional test without load shall demonstrate that the arm locking system resists the stipulated values (see 5.9.5).

6.1.5.5 Electrical tests

Electrical tests shall be performed according to EN 60204-1:2006.

7 Information for use

7.1 General

Information for use may consist of text, words, signs, signals or diagrams, used separately or in combination.
It is directed to the installer and the user.
The information of use is an integral part of the supply of the vehicle lift.
This information shall comply with Clause 6 of EN ISO 12100-2:2003 and with the following provisions.

7.2 Marking

The following information shall be fixed on the lift and shall be readily visible:
a) the rated load in kilograms or tonnes;
b) the allowable load distribution if the rated load depends on it;
c) the unladen weight in kilograms or tonnes if the lift is movable or mobile;
d) a warning sign "travelling on the load carrying devices is forbidden" if the lift is not designed for this
purpose;
e) hydraulic supply information if an external hydraulic power supply is used;
f) pneumatic supply information if an external pneumatic power supply is used;

g) electrical supply information if an external electric power supply is used;
h) if the vehicle lift is designed for outside use specific information about safe use of the lift when exposed to
wind effect, in which the maximum allowed wind speed exposure for each type of normative vehicle is
shown (refer to Annex D (informative)).

7.3 Operation instructions

7.3.1 Complete operation instructions

A complete operation manual containing the information for safe use and operation of the lift shall be supplied
with each lift.
This manual shall include at least the following information:
a) range of application (use, misuse);
b) installation and commissioning;
c) handling and behaviour while operating the lift;

d) monitoring of the safety devices;
e) maintenance;
f) inspection;
g) trouble shooting;
h) replacement of parts, e.g. due to wear or operation of safety devices;
i) if applicable charging of batteries and ventilation of the room;
j) the vehicle lift shall be operated with respect to the complete operating instructions;
k) only authorized persons shall operate the lift;
l) in the case of multiple lifting units, the rated load of each unit and guidance on safe combined rated loads
shall be provided;
m) in case that persons are permitted to stand under the vehicle during lifting and lowering the following
hints:
1) special training has to be given to the operator and the persons which are permitted to stand under
the vehicle during lifting and lowering;
2) during normal operation no persons are permitted to stand under the vehicle;
3) persons are only permitted to stand under the moving load in extreme circumstances where movements of the load should be kept as short as possible;
n) the additional release switch(es), if appropriate, shall be located in such a way that from these locations
together with the normal operating position the whole hazardous area can be monitored;
o) maximum permissible wind speed according to 5.7.2.2 and 5.7.2.3, if appropriate.
In cases b), e) and f) the information shall also include necessary information concerning the strength of
foundations and necessary inspection traps in the floor.

In the event of the vehicle lift being first assembled at the user's site, the operation instructions shall contain a
statement that it shall be checked that the vehicle lift and the associated safety and protective devices are
correctly installed and function in a proper manner. The procedure shall be written in the operation manual.

7.3.2 Digest of the operation instructions

A digest of the operation instructions containing at least the following information taking into account possible
hazards existing for the lift where applicable for the safe operation shall be fixed on the lift and shall be readily
visible.
a) The operation of the lift is permitted by authorised persons only.
b) It is necessary to refer to the complete operation instructions, especially for trouble shooting.
c) Movable and mobile lifts shall be prevented from moving unintentionally.
d) The field of motion of the load and of the load carrying devices shall be free of obstructions.
e) It shall draw attention to the safe method of carrying the load and to the rule that, after raising a short
distance, the vehicle shall be checked to ensure that it is correctly and safely positioned.
f) It shall draw attention to the rule that the load carrying device shall be observed by the operator throughout the motion of the lift.
g) It is forbidden for people to stand in the field of motion of the load and the load carrying device during the
movement, if appropriate.
h) It is forbidden to climb onto the load or load carrying device when they are raised unless via a specifically

designed access.
i) Maximum permissible wind speed according to 5.7.2.2 and 5.7.2.3, if appropriate.

7.4 Name plate

A durable name plate with following information shall be permanently fixed on the lift (refer to Annex B
(informative)) and shall be readily visible:
a) business name and full address of the manufacturer and, where applicable, his authorised representative;
b) country of manufacture;
c) designation of the machinery;
d) designation of series or type;
e) serial number;
f) year of construction, that is the year in which the manufacturing process is completed.

Annex A

(informative)

Structural calculations

A.1 Permissible stresses

A.1.1 General

Symbols

f_y (R_{EH}) $[N/mm^2]$ *Yield strength*

f_u (R_m) $[N/mm^2]$ *Ultimate strength*

$E = 210\,000\ [N/mm^2]$ *Modulus of elasticity*

$G = \frac{E}{2 \cdot (1+\nu)}$ $[N/mm^2]$ *Shear modulus*

$\nu = 0{,}3$ *Poisson's ratio*

A_5 [%] *Elongation at failure on gauge length of five times the diameter of the original cross section*

t [mm] *Nominal thickness*

Nominal values of material properties for standardised structural steels (EN 10025-2:2004), see Table A.1.

Table A.1 — Material properties (in N/mm2)

Nominal thickness of the element			
$t \leq 40$ mm		40 mm < $t \leq 80$ mm	
fy	*fu*	*fy*	*fu*
S 235			
S 275			
S 355			
235			
275			

355
360
430
510
215
255
335
360
410
470

A.1.2 Standardised structural steels

Permissible stresses

$\sigma_a = fy/s$

where

s is the safety factor depending on the load combination A, B or C, as shown in the following Table A.2.

Table A.2 — Permissible stresses (in N/mm2)

Load

combination

A B C

***s* = 1,5 *s* = 1,33 *s* = 1,25**

S 235 S 275 S 355 S 235 S 275 S 355 S 235 S 275 S 355

Basic material

and butt joint

$\sigma_a = \sigma_0$ 157 183 237 176 206 266 188 220 284

$\tau_a = \sigma_0 / 3$ 90 106 137 102 119 154 109 127 164

Fillet weld

$\sigma_a = \sigma_0$ 157 183 237 176 206 266 188 220 284

$\tau_a = \sigma_0 / 2$ 111 130 167 125 146 188 133 156 201

The indicated permissible stresses are valid up to a thickness of 40 mm: in case of greater thickness the

corresponding value of *fy* shall be taken into consideration.

Selecting the materials special requirements shall be taken into account, e.g.:

- weldability;
- use of the appliance in extreme climate zones.

A.1.3 Bolts

a) Bolts

The permissible stresses are derived from X, which is the lower value of *fy* and 0,7 · *fu* (see Table A.3).

$\sigma_a = X / s \quad \tau_a = \sigma_a / 2$

Table A.3 — Permissible stresses for bolts (in N/mm2)

Load

combination *s*

Grade

fy

X

4.6

240

240

5.6

300

300

6.6

360

360

6.8

480

420

8.8

640

560

10.9

900

700

A 1,5 $\int_a$ 160 200 240 280 373 467

$|_a$ 113 141 170 198 264 330

B 1,33 $\int_a$ 180 225 270 315 420 525

$|_a$ 127 159 191 223 297 371

C 1,25 $\int_a$ 192 240 288 336 448 560

$|_a$ 136 170 204 238 317 396

b) Preloaded bolts

Grade 8.8 and 10.9 only

Symbols

$A_s\,[mm^2]$ *tensile stress area of bolt*

$F_v\,[N]$ *preload*

$d\,[mm]$ *bolt diameter*

$M_t\,[Nm]$ *tightening*

Bolts used one time $F_v = 0{,}8 \cdot fy \cdot A_s$

Bolts used several times $F_v = 0{,}7 \cdot 0{,}8 \cdot fy \cdot A_s$

Tightening M_t H $0{,}18 \cdot d \cdot F_v / 1\,000$

c) Bearing pressure

The permissible bearing pressure $\int_L$ depends on the basic material and is not only valid for bolt connections

but also for axles (see Table A.4).

Articulation $\sigma_L = 1{,}3 \cdot \sigma_0$
Clearance joint $\sigma_L = 1{,}5 \cdot \sigma_0$
Fitted joint $\sigma_L = 2{,}0 \cdot \sigma_0$

Table A.4 — Bearing pressure (in N/mm2)

Load

combination

A B C

S 235 S 275 S 355 S 235 S 275 S 355 S 235 S 275 S 355

Articulation 204 238 308 229 268 346 244 286 369

Clearance joint 235 275 335 264 309 399 282 330 426

Fitted joint 313 367 473 352 412 532 376 440 568

A.1.4 Non-standardised structural steels

Depending on the minimum values of the ultimate strength *fu*, the yield strength *fy* and the elongation at
failure ε_5 an ideal yield strength *fyi* is to be defined taking into consideration the following conditions:
a) $f_y \leq 0{,}7 \cdot f_u$ $f_{yi} = f_y$
b)
f_u
f_u
<
$< \delta$
590
510 590
9 800
10 800
ε_5
ε_5
$\cdot \varepsilon$
$\cdot \varepsilon$
f_u
f_u
ε_M
ε_M

If this condition is fulfilled, the following applies:

$f_{yi} = 0{,}8 \cdot f_u$
If this condition is not fulfilled, the following applies:
9 600
$26\,000 \square \cdot (6 + \varepsilon_5)$
$= r\, f_u$
$1{,}28 \leq r \leq 1{,}44$
$f_{yi} = f_u / r$
Based on *fyi* the permissible stresses shall be calculated with the safety factors s given for general structural
steels.

A.1.5 Combined stress

Structural parts and butt joints:
σ_x^2
$\sigma_x \sigma_y$

2
y
2
∫ = ∫ x + ∫ □ ∫ · ∫ + 3· |
Bolts, axles and fillet welds:
2
x y
2
y
2
∫ = ∫ x + ∫ □ ∫ · ∫ + 2· |

A.1.6 Elastic stability

a) Crippling

Symbols
crippling factor
specific slenderness
slenderness
=
=
=
⌉
⌊
⌊
'

The crippling factor ⌉ is defined in the following way:
1,195 ' 3
0 ' 1,195
' / /
< δ
< δ
= ·
⌊
⌊
⌊⌊ *fy E* □
2
2,5
1,465 '
1/(1 0,195 ' 0,185 ')
⌉⌊
⌉⌊⌊
= ·
= □ · □ ·

The highest permissible slenderness is ⌊ = 250.

b) Buckling

The critical buckling stress ∫vki is defined in the following way:
∫ vki < 0,7 · *fy* ∫ vk = ∫ vki
∫ vki ε 0,7 · *fy* 4 1,4
∫ vk = *fy* · 1□ 0,461/(∫ vki / *fy*)

Annex B
(informative)

Examples of solutions

This annex predominantly comprises solutions describing methods by which the requirements of the normative text can be fulfilled.

To 3.1

Figure B.1 — Two-column-lift

Figure B.2 — Four-column-lift

Figure B.3 — Scissor-lift Figure B.4 — Two-cylinder-lift

To 5.2

This requirement can be fulfilled as follows:

a) a safety switch with a key that can only be taken out after the lift has stopped; or

b) a push-button that locks automatically and can only be released with a security key; or

c) an interlockable main switch according to 5.3.2, a), b) or c) of EN 60204-1:2006.

To 5.3.3

For the lifting and lowering operation this requirement can be fulfilled as follows (see Figures B.5 to B.11):

a) where buttons are used, if the button for the raising movement is positioned above or to the right of the
button for the lowering movement (see Figure B.5);

or

a) b)

Key

1 down

2 up

Figure B.5 — Arrangement of buttons

b) where foot operated buttons are used, if the button for the raising movement is positioned to the right of
the button for the lowering movement (see Figure B.6);

or

a) b)

Key

1 down

2 up

Figure B.6 — Arrangement of foot operated buttons

c) where horizontal levers are used:

1) if upward movement of the lever generates the raising movement and the downwards movement of
the lever generates the lowering movement (see Figure B.7);

Key

1 down

2 up

Figure B.7 — Up and down movement of

horizontal levers (side elevation)

2) if the movement of the lever to the right generates the raising movement and the movement of the lever to the left generates the lowering movement (see Figure B.8);

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Key
1 down
2 up

Figure B.8 — Left and right movement

of horizontal levers (plan view)

d) where vertical levers are used, if the movement of the lever towards the human body generates the
raising movement and the movement of the lever away from the human body generates the lowering movement (see Figure B.9);

Key
1 down
2 up

Figure B.9 — Movement of vertical levers

e) where pedals are used, if the pedal for the raising movement is on the right and for the lowering movement on the left (see Figure B.10);

Key
1 down
2 up

Figure B.10 — Arrangement of pedals

f) where hand wheels are used, if turning the wheel to the right starts the raising movement and turning it to
the left starts the lowering movement (see Figure B.11);

Key
1 down
2 up

Figure B.11 — Movement of hand wheels

To 5.3.4
The requirement "permanently marked" is e.g. fulfilled, if the following test is passed:
Rubbing the marking by hand for 15 s with a piece of cloth soaked with petroleum spirit. After this test the
marking shall be easily legible, it shall not be easily possible to remove marking plates and they shall show no
curling.
To 5.3.5
This requirement can be fulfilled as follows:
a) Push-buttons: The button shall not be larger than is necessary for it to be operated by one finger of a
hand wearing a protective glove. A ring shall surround the button, with minimal clearance, and no part of
the button shall protrude above the ring.
b) Foot operated buttons: The space above the button shall be completely covered. The distance between
the button and the cover should be approximately 70 mm. A rectangular tubular section approximately
15 mm high should surround the button to protect it from access from the sides (see Figure B.12).
Dimensions in millimetres

Figure B.12 — Covering of foot operated buttons

c) Hand levers: The lever should automatically lock in its home position.
d) Hand wheels: Shall be round, solid and have no burrs or sharp edges.
If it is necessary to use more than one control device simultaneously to operate the lift then it is sufficient if
only one of them is protected against unintentional operation.
To 5.8.1
Self-braking screws as load carrying device fulfil this requirement. For hydraulically driven lifts, pilot operated
non-return valves in the oil supply and oil return lines fulfil this requirement.

To 5.8.2
Examples of self locking means include non-return valves which lock the hydraulic pressure medium in the
cylinder, latches and self-braking systems.
To 5.8.5.2
The requirement is fulfilled if, for example, a system consisting of hooks and latches is provided.
To 5.8.5.4
The requirement is fulfilled if for example, a pressure reduction valve is fitted.
To 5.12
The requirement "to cut the drive power" is fulfilled, if the control circuit is cut.
For vehicle lifts where the load carrying devices are suspended on wire ropes or chains, a safety switch
should cut off the drive in the event of a slack rope or chain. The same effect is also required for screw driven
vehicle lifts and those with hydraulic bearing devices if the load carrying device is not fixed to the load bearing
nut or hydraulic cylinder. In this case the lowering movement shall be stopped by means of a switch which
detects separation of the load carrying device and the nut or cylinder.
To 5.13.1
The requirement is fulfilled if, for example:
| a mechanical, automatic system consisting of hooks and latches; or
| unloaded accompanying bearing devices according to 5.13.2
is provided.
To 5.14.2
This requirement shall be fulfilled by means of a mechanical locking device consisting of hooks and latches or
other systems (e.g. mechanical connectors between cylinders with independently non-return valves) that
prevent moving.
It is assumed that not more than one leakage in the circuit is considered at the same time.
To 5.15
The requirement can be fulfilled by use of control systems or by mechanical connecting systems (e.g. chains
or cardan shafts).
The requirement also means that chains used for the transmission of power between lift screws should be
provided with a slack chain switch or similar device which prevents dangerous desynchronisation of the load
carrying devices in the event of a broken or disengaged chain.
To 5.16.1
In the case of mobile vehicle lifts the requirement is fulfilled if there are:
a) lockable parking brakes on at least two wheels; or
b) spring loaded wheels in at least two positions so that the loaded lift cannot be moved; or

c) supports lifting at least two wheels from the ground; or
d) at least one automatically retractable wheel when the load is applied.

To 5.18.4

The requirement is fulfilled:

- if re-raising from the initial position is prevented in situations where unloaded accompanying bearing devices are fitted according to 5.13.2;
- in all other cases if all motions are stopped.

To 5.18.5

This requirement can be fulfilled by the use of compression springs with both ends fixed or by selection of springs such that the wire diameter is greater than the distance between the coils, hence preventing the two pieces from winding into each other in the event of a breakage.

To 5.20

Requirement c) is e.g. fulfilled if:

- securing mechanisms such as snap-in latches or locking springs are fitted; or
- the distance that winding handles or levers up to a length of 250 mm can be pushed in their shafts is at least one-fifth of their own length.

To 7.4

The requirement "permanently fixed" is fulfilled, for example, if tools are required to fix and remove the nameplate. Stamped letters and numbers also fulfil this requirement.

Annex C

(normative)

Design of rope drives

The minimum rope diameter is determined by the following formula:

$$d = c \sqrt{F}$$

where

d is the minimum rope diameter, in millimetres;
c is a factor (see Table C.1);
F is the calculated traction force, in newtons;
ηs is the efficiency of the rope drive.

The efficiency of a rope drive, for calculation of the rope traction force is determined in accordance with the following formula:

$$( ) ( ) ( )$$

R
n
i R
F R

i
s R 1
1 1
|
| | | | |
□
= · = · · □
n
where
η_F is the efficiency of the pulley block;
( )
R
n
R
F 1
1 1
|
|
|
□
□
= ·
n
;
η_R is the efficiency of one pulley block;
for anti friction bearings
for sliding bearings
0,98
0,96
R
R
=
=
|
|
i is the number of fixed pulleys between the rope, drum and the load;
n is the number of rope plies in one pulley block. One pulley block consists of the sum total of all the rope plies and rope pulleys for one rope winding onto a rope drum.

Table C.1 — Factor *c*

Nominal strength of the wires in newtons per square millimetre	*c*
1570	0,095
1770	0,095
1960	0,09

The pitch diameter of rope drums shall have at least 18 times the diameter of the rope.
The pitch diameter of rope pulleys shall have at least 20 times the diameter of the rope.

Annex D
(informative)
Example of information about wind

Table D.1 — Information about wind

Vehicle type Empty weight t	Max. allowed wind speed m/s
Cars, caravans, long swap lorries from 1 to 10	14
Bus, articulated lorries from 10 to 15	20
Lorries and heavy vehicles greater than 15	24

Annex E
(normative)
Protection against leakage

Table E.1 — Protection against leakage

Drive system	EN 1493 Clause	Measure
(1) One cylinder	5.8.1 (Inadvertent motion)	(Pilot operated) non return valves[a]
	5.8.2 (Holding devices)	Pilot operated non return valves[a] or latches
	5.13.1 (Safety catch)	Not applicable (applies only to mechanical bearing devices)
	5.13.2 (Accompanying bearing devices)	Not applicable (applies only to mechanical bearing devices)
	5.14.1 (Limiting lowering speed)	Restrictor (max. 1,5 · lowering speed)
	5.14.2 (Protection against leakage)	Not applicable for hydraulic drives (latches are required in EN 1493, but the risk is considered to be low)
(2) Two independent cylinders	5.8.1 (Inadvertent motion)	(Pilot operated) non return valves[a]
	5.8.2 (Holding device)	(Pilot operated) non return valves[a] or latches
	5.13.1 (Safety catch)	Not applicable (applies only to mechanical bearing devices)
	5.13.2 (Accompanying bearing devices)	Not applicable (applies only to mechanical bearing devices)
	5.14.1 (Limiting lowering speed)	Restrictor (max. 1,5 · lowering speed)
	5.14.2 (Protection against leakage)	Two latches or total hydraulic redundancy per drive system
(3) Two cylinders Mechanically connected (each cylinder designed		

to carry the total load)
5.8.1 (Inadvertent motion) (Pilot operated) non return valvea on each cylinder
5.8.2 (Holding device) (Pilot operated) non return valvesa or latches
5.13.1 (Safety catch) Not applicable (applies only to mechanical bearing
devices)
5.13.2 (Accompanying bearing
devices)
Not applicable (applies only to mechanical bearing
devices)
5.14.1 (Limiting lowering speed) Restrictor (max. 1,5 · lowering speed)
5.14.2 (Protection against leakage) Pilot operated non return valvea on each cylinder
(only one leakage considered)
(4) One cylinder + one
rope/chain per
suspension point
5.8.1 (Inadvertent motion) (Pilot operated) non return valvesa
5.8.2 (Holding device) Pilot operated non return valvea or latches
5.13.1 (Safety catch) Catching device (activated by an overspeed
governor or chain/rope failure detector)
5.13.2 (Accompanying bearing
devices)
Not used (applies only to two or more ropes/chains)
5.14.1 (Limiting lowering speed) Restrictor (max. 1,5 · lowering speed)

Table E.1 *(continued)*

Drive system EN 1493 Clause Measure

5.14.2 (Protection against leakage) Not applicable (latches are required in EN 1493, but
the risk is considered to be low)
(5) One cylinder + two or
more ropes/chains per
suspension point
5.8.1 (Inadvertent motion) (Pilot operated) non return valvesa
5.8.2 (Holding device) Pilot operated non return valvea or latches
5.13.1 (Safety catch) Not used (because of 5.13.2)
5.13.2 (Accompanying bearing
devices)
rope/chain failure detector
5.14.1 (Limiting lowering speed) Restrictor (max. 1,5 · lowering speed)
5.14.2 (Protection against leakage) Not applicable (latches are required in EN 1493, but
the risk is considered to be low)
(6) Spindle system(s) with
safety catch
5.8.1 (Inadvertent motion) Self braking system or additional brake
5.8.2 (Holding device) Self braking system or holding device
5.13.1 (Safety catch) Catching device
5.13.2 (Accompanying bearing
devices)
Not applicable
5.14.1 (Limiting lowering speed) Not applicable
5.14.2 (Protection against leakage) Not applicable
(7) Spindle system(s) with
safety nut
5.8.1 (Inadvertent motion) Self braking system or additional brake
5.8.2 (Holding device) Self braking system or holding device
5.13.1 (Safety catch) Not applicable
5.13.2 (Accompanying bearing
devices)
Safety nut
5.14.1 (Limiting lowering speed) Not applicable

5.14.2 (Protection against leakage) Not applicable
a Valve, which is opened by force (hydraulic, pneumatic, electric) see 9.3.2.2.2 of ISO 1219-1:2006.

Definitions:

hydraulic and pneumatic circuit

all components, such as pipes, hoses, relief valves, non return valves, cylinders and connections

leakage (it is assumed that only one leakage occurs in the circuit. The lowering of the vehicle will always be limited to 1,5 times the normal lowering speed.)

external or internal failure with any value of flow, e.g. external leakage: rupture of a hose
internal leakage: non return valve not properly closed or failure of cylinder seal

drive system

unit for lifting the vehicle; a vehicle lift can be provided with one or more drive systems

holding device (see 5.8.2)

device, which holds the load bearing device automatically in its inoperative position by self locking means

catching device (see 3.14)

device, which holds the load carrying device in case of failure of the load bearing device

Annex F

(normative)

Additional requirements for cableless controls and control systems

F.1 Introduction

Cable-less controls shall be designed according to 9.2.7 of EN 60204-32:2008 with the following additions.

F.2 General

The cableless control station shall not send any moving command whilst the means to prevent unauthorised
use is activated.

F.3 Control limitation

F.3.1 Activation of the cableless control station and the data communication shall be indicated on the cableless control station and shall not initiate any movement of the vehicle lift.

F.3.2 A moving command shall only be active when the receiver receives a correct message. For detailed
requirements see F.5.

F.3.3 A moving command received by a message shall only be accepted if at least one correct message
without any moving commands is received first.

F.3.4 To avoid inadvertent movements after any situation having caused the lift to stop (e.g. power supply
fault, battery replacement or lost signal condition), the system shall only output operating commands resulting
in any lift movement after the operator has returned the controls to "off" position for a suitable period of time,
i.e. it has received at least one frame without any operating commands.

F.4 Stop

The part of the cableless control system to perform the emergency stop function is a safety related part of the
lifts control system, as defined in 3.1.1 of EN ISO 13849-1:2008. This part of the cableless control system
shall be designed to performance level d or higher according to EN ISO 13849-1:2008.

F.5 Serial data communication

F.5.1 When data communication is used in the implementation of a safety function then the residual error
rate of the communication process shall be estimated taking into account transmission errors, repetitions,
deletion, insertion, re-sequencing, corruption, delay and masquerade. This residual error rate shall be taken
into account when estimating the performance level of the safety function due to random failures.
Table F.1 shows the failures which shall be taken into consideration and corresponding safety measures.

Table F.1 — Failures and safety measures

Communication errors	Safety measures								
	Sequence number	Time stamp	Time expectation	Connection authentication	Feedback message	Data integrity assurance	Redundancy with cross checking	Different data integrity assurance systems	
Corruption	X	X							Only for serial bus [d]
Unintended repetition		X	X				X	X	
Incorrect sequence		X	X				X	X	
Loss			X				X	X	
Unacceptable delay			X						[c]
Insertion		X	X	[a,b]	X	[a]	X		
Masquerade		X	[a]	X	[a]	X			
Addressing				X					

NOTE Table adapted from IEC 62280-2.

a Depends on application.

b Only for sender identification. Detects only insertion of an invalid source.

c Required in all cases.

d This measure is only comparable with a high quality data assurance mechanism if a calculation can show that the residual error rate
ə reaches the values required in 5.4.9 when two messages are sent through independent transceivers.

F.5.2 There shall be a continuous data communication so that communication faults (e.g. deletion) are
detected by the system.

F.5.3 The residual error rate is calculated from the residual error probability of the superimposed (safety)
data integrity assurance mechanism and the transmission rate of safety messages. In addition, one shall take
into account for the assessment the maximum number of information sinks (m) that is permitted in a single
safety function.

Table F.2 — Relationship of residual error rate to performance level pl

Application for safety functions up to pl	Probability of a dangerous failure per hour for the functional safety communication system	Maximum permissible residual error rate for the functional safety communication system
e	$< 10^{-9}$ / h	ə $< 10^{-9}$ / h
d	$< 10^{-8}$ / h	ə $< 10^{-8}$ / h
b/c	$< 10^{-7}$ / h	ə $< 10^{-7}$ / h

NOTE Values in this table are based on the assumption that the functional safety communication system contributes
no more than 1 % of the total failures of the safety function.

Equation (F.1) shown below shall be used to calculate the residual error rate resulting from RSL (Pe), unless
the underlying model does not apply, or if another method may be more relevant. Items of the formula are
specified in Table F.3.

$$\text{ə}_{SL}(Pe) = RSL(Pe) \cdot v \cdot m \quad \text{(F.1)}$$

NOTE This formula assumes cyclic transmission of safety messages.

Table F.3 — Formula items

Formula items	Definition
$\text{ə}_{SL}(Pe)$	Residual error rate per hour of the safety communication layer with respect to the bit error probability.
Pe	Bit error probability. Unless a better error probability can be proven, a value of 10^{-2} shall be used.
$R_{SL}(Pe)$	Residual error probability of a safety message.
v	Maximum number of safety messages per hour.
m	Maximum number of information sinks that is permitted in a single safety function.

F.5.4 The control system shall initiate a stop of all lift movements when no valid frame has been correctly
received within 1,0 s. The foreseen usage of the lift shall be tested to ensure that additional hazards do not
result from this extension of the time value.

F.6 Use of more than one operator control station

F.6.1 Where a machine has more than one control station, measures shall be provided to ensure that
initiation of commands from different control stations do not lead to a hazardous situation.

F.6.2 Means shall be provided to enable several transmitter/receiver pairs to operate in the transmission
range without unwanted interference with each other.

F.6.3 The means provided in F.6.2 shall be protected from accidental or unintentional change.

F.7 Battery-powered operator control stations

A variation in the battery voltage shall not cause a hazardous situation. If one or more potentially hazardous
motions are controlled using a battery-powered cableless operator control station, a clear warning shall be
given to the operator when a variation in battery voltage exceeds specified limits. Under those circumstances,
the cableless operator control station shall remain functional long enough for the operator to put the vehicle lift
into a non-hazardous situation.

NOTE A time period of 10 min is normally acceptable.

F.8 Wireless control components

The wireless control components (transmitter and receiver) shall have sufficient mechanical strength against
environmental influences and expected loads, such as vibration and bump.

NOTE See e.g. IEC 60068-2-6, IEC 60068-2-27, IEC 60068-2-75, IEC 60068-2-31.

Annex G

(normative)

Noise

Generally noise is not considered to be a significant hazard for this type of machinery.
Therefore there is no special test method for noise in this standard.
This does not absolve the manufacturer of machines with a noise emission exceeding the criteria of the
Machinery Directive of the responsibility to provide information about the noise emission in the information for
use of the machine.
Any vehicle lift that produces a noise emission value of more than 70 dB(A) measured at 1,0 m from the major
noise source shall have this measured value specified in the manual. If this value does not exceed 70 dB(A)
this fact should be stated in the manual.
The operating conditions of the machine while under test and the test methods used to produce these figures
should also be given in this manual.

Annex ZA

(informative)

Relationship between this European Standard and the Essential Requirements of EU Directive 2006/42/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission
and the European Free Trade Association to provide a means of conforming to Essential Requirements of the
New Approach Directive 2006/42/EC.
Once this standard is cited in the Official Journal of the European Union under that Directive and has been
implemented as a national standard in at least one Member State, compliance with the normative clauses of
this standard confers, within the limits of the scope of this standard, a presumption of conformity with the
relevant Essential Requirements of that Directive and associated EFTA regulations.

WARNING — Other requirements and other EU Directives may be applicable to the product(s)

falling

within the scope of this standard.

Bibliography

[1] EN 10025-2:2004, *Hot rolled products of structural steels — Part 2: Technical delivery conditions for*
non-alloy structural steels
[2] EN 1760-2:2001+A1:2009, *Safety of machinery — Pressure sensitive protective devices — Part 2:*
General principles for the design and testing of pressure sensitive edges and pressure sensitive bars

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BRITISH STANDARD BS EN 1495:1997

Lifting platforms — Mast climbing work platforms

ICS 53.020.99

+A2:2009

National foreword

This British Standard is the UK implementation of EN 1495:1997+A2:2009. It supersedes BS EN 1495:1998, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags !". Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment 1 is indicated by !".

The UK participation in its preparation was entrusted to Technical Committee MHE/12, Lifting platforms.

A list of organizations represented on this committee can be obtained on request to its secretary.

The UK as a member of CEN is obliged to publish EN 1495:1997/A1:2003 as a British Standard. However, attention is drawn to the fact that during the development of A1:2003, the UK voted against its approval. The reason for this disapproval is that, where The Construction (Health, Safety and Welfare) Regulations 1996 Statutory Instrument 1996 No. 1592 requires the main guardrail, or other similar means of protection, to be at least 910 mm above the edge from which any person is liable to fall, this standard specifies 700 mm high guardrails. Attention is also drawn to The Work at Height Regulations 2005 which also sets the minimum main guardrail height at 910mm.

The textual error set out below was discovered when the English language version of EN 1495:1997/A1:2003 was adopted as a national standard. It has been reported to DIN in a proposal to amend the text of the European Standard.

Table 1.1 — List of hazards (Part 1)

Item 11.9 Essential equipment and accessories for safe adjusting and/or maintaining: **5.4.2.10** should read **5.4.2.9**.

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EUROPÄISCHE NORM

EN 1495:1997+A2

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English Version

Lifting platforms - Mast climbing work platforms

Matériels de mise á niveau - Plates-formes de travail se
déplaçant le long de mât(s)
Hebebühnen - Mastgeführte Kletterbühnen

This European Standard was approved by CEN on 21 April 1997 and includes Corrigendum 1 issued by CEN on 11 December 1997,
Amendment 1 approved by CEN on 1 September 2003 and Amendment 2 approved by CEN on 19 June 2009.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents Page

Foreword

This document (EN 1495:1997+A2:2009) has been prepared by Technical Committee CEN/TC 98 "Lifting platforms", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2010, and conflicting national standards shall be withdrawn at the latest by January 2010.

This European Standard was approved by CEN on 21 April 1997 and includes Corrigendum 1 issued by CEN on 11 December 1997, Amendment 1 approved by CEN on 1 September 2003 and Amendment 2 approved by CEN on 19 June 2009.

This document supersedes EN 1495:1997.

The start and finish of text introduced or altered by amendment is indicated in the text by tags ! " and # $.

The modifications of the related CEN Corrigendum have been implemented at the appropriate places in the text and are indicated by the tags ˜ ™.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

#For relationship with EU Directive(s), see informative Annexes ZA and ZB, which are integral parts of this
document.$
It is a type C- standard related to safety for Mast Climbing Work Platforms.
#deleted text$
According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following
countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech
Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia,
Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain,
Sweden, Switzerland and United Kingdom.

Introduction

This standard is one of a series of standards produced by CEN/TC 98 as part of the CEN/CENELEC programme of work to produce machinery safety standards. EN 414 (Safety of machinery – Rules for the
drafting and presentation of safety standards) has been used as a guide in the preparation of this standard.
This standard has been prepared to be a harmonized standard to provide one means of conforming with the
essential safety requirements of the Machinery Directive.
The extent to which hazards are covered is indicated in the scope of this standard. In addition, lifting equipment shall comply as appropriate with !EN ISO 12100" for hazards which are not covered by this
standard.

1 Scope

1.1 This standard specifies the special safety requirements for Mast Climbing Work Platforms (MCWP) which
are temporarily installed and are manually or power operated and which are designed to be used by one or
more persons from which to carry out work. The vertical moving components (work platform) are also used to
move those same persons and their equipment and materials to and from a single boarding point. These
restrictions differentiate MCWPs from Builder's hoists.
The standard can also be used for permanently installed MCWP.

1.2 This standard is applicable to work platforms elevated by rack and pinion and guided by and moving
along their supporting masts, where the masts may or may not require lateral restraint from separate supporting structures.

1.3 This standard is applicable to any combination of the following alternatives:

- One or more masts;
- Mast tied or untied;
- Mast of fixed or variable length;
- Masts vertical or inclined between 0° and 30° to th e vertical;
- Masts which are standing or hanging;
- Movable or static base (chassis, or base frame);

| Manually or power operated elevation;
| Towed or self powered ground travel on site, excluding road traffic regulation requirements;
| Driven using electric, pneumatic or hydraulic motors.

1.4 This standard identifies the hazards arising during the various phases in the life of such equipment and
describes methods for the elimination or reduction of these hazards and for the use of safe working practices.

1.5 This standard does not specify the requirements for dealing with the hazards involved in the manoeuvring,
erection or dismantling, fixing or removing of any materials or equipment which are not part of the Mast
Climbing Work Platform (MCWP). Neither does it deal with the handling of specific hazardous materials.

1.6 This standard does not specify the requirements for delivering persons and materials to fixed landing
levels. Such equipment is referred to as lifts or hoists and are dealt with by other standards.

1.7 This standard does not include Mobile Elevating Work Platforms (MEWPs) according to #EN 280$,
Suspended access equipment according to #EN 1808$ or Lifting tables according to #EN 1570$.

2 Normative references

#The following referenced documents are indispensable for the application of this document. For dated
references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.$
#deleted text$
EN 294:1992, *Safety of machinery — Safety distances to prevent danger zones being reached by the upper
limbs*
EN 349:1993, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*
EN 418:1992, *Safety of machinery — Emergency stop equipment, functional aspects – Principles for design*
EN 614-1:1995, *Safety of machinery — Ergonomic design principles — Part 1: Terminology and general
principles*
EN 953:1997, *Safety of Machinery — General requirements for the design and construction of guards (fixed,
movable)*
EN 954-1:1996, *Safety of Machinery — Safety-related parts of control systems — Part 1: General principles
for design*
EN 982:1996, *Safety of machinery — Safety requirements for fluid power systems and components —
Hydraulics*
EN 60065:1993, *Safety requirements for mains operated electronic and related apparatus for household and
similar general use*
EN 60204-1:1992, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*
EN 60529:1992, *Degrees of protection provided by enclosures (IP code)*

EN 60947-5-1:1991, *Low-voltage switchgear and controlgear — Part 5: Control circuit devices and switching*
elements — Section 1: Electromechanical control circuit devices and switching elements
#EN ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1:*
Basic terminology, methodology (ISO 12100-1:2003)
EN ISO 12100-2:2003, *Safety of machinery — Basic concepts, general principles for design — Part 2:*
Technical principles (ISO 12100-2:2003)$
ISO 4301-1:1986, *Cranes and lifting appliances — Classification — Part 1: General*
ISO 4302:1989, *Cranes — Wind load assessment*

ISO 6336-1, *Calculation of load capacity of spur and helical gears — Part 1: Basic principles, introduction and*
general influence factors
ISO 6336-2, *Calculation of load capacity of spur and helical gears — Part 2: Calculation of surface durability*
(pitting)
ISO 6336-3, *Calculation of load capacity of spur and helical gears — Part 3: Calculation of tooth strength*
ISO 6336-5, *Calculation of load capacity of spur and helical gears — Part 5: Strength and quality of materials*
ISO 8686-1:1989, *Cranes — Design principles for loads and load combinations — Part 1: General*

3 Definitions

For the purposes of this standard the following definitions apply:
NOTE The terms which are used in this standard, with reference to the definitions below, are indicated in figures 1
and 2.

3.1

rated load

the loads for which the MCWP has been designed for in normal operation as stated in the load diagram

3.2

load diagram

a notice displayed on the work platform showing the permitted number of persons and the weight and
distribution of materials for the particular configuration

3.3

rated speed

the vertical or horizontal speed for which the MCWP has been designed

3.4

transfer

any horizontal movement of the MCWP from one position to another on the same working site

3.5

transfer condition

the configuration of the MCWP in which the MCWP is moved from one position to another on the same
working site and any limitation on the weather and the load or persons on the MCWP

3.6

transport

any movement of the MCWP outside the boundaries of the working site

3.7

transport condition

the configuration of the MCWP in which the MCWP is moved outside the boundaries of the working site (for
example road transport)

3.8

transfer and transport interlocks

any design features on the MCWP which prevent unsafe transfer or transportation

3.9

base frame

the part of the MCWP which provides support for the mast and elevating assembly

3.10

chassis

the part of the MCWP which provides mobility and support for the mast and elevating assembly

3.11

rail mounted chassis

a chassis designed to transmit horizontal as well as vertical forces to the ground via rails

3.12

outriggers

Supports at the base frame level used to maintain or increase the stability of the MCWP within specified
conditions. They may also be used for levelling.

3.13

outrigger beam

that part of an outrigger assembly which moves in a substantially horizontal plane and may be powered or
operated manually

3.14

mast

a structure that supports and guides the platform

3.15

mast, fixed length

a mast whose length is fixed and cannot be varied, even by the attachment of further mast sections

3.16

mast, variable length

a mast whose length can be varied by the attachment of successive lengths of prepared sections

3.17

guides

the parts of the mast, which provide guiding for the work platform

3.18

mast tie

the anchorage system used to provide lateral restraint to the mast from the building or other structure

3.19

work platform

The vertical travelling part of the installation upon which the persons, equipment and materials are carried and
from which work is carried out. This is as opposed to the MCWP, which refers to the whole of the installation,
inter alia work platform, mast, mast ties, base and chassis. The work platform includes the main platform and
any platform extension.

3.20

available platform area

the area of the work platform measured at the work platform floor level

3.21

main platform

that part of the work platform which is built up using primary structural elements

3.22

platform extensions

those additional parts of the work platform which are built up using secondary structural elements, whose
support and location is dependent upon the main platform. They are used to extend the main work platform,
usually along its longitudinal working edge. They may form irregular shapes which conform to the work site.
They may also extend at a level just above or below the main platform level.

3.23

multilevel work platforms

multilevel work platforms consist of two or more work platforms travelling on the same mast or an additional
working level attached to and totally supported by a work platform. (For illustration see annex B)

3.24

counter roller

a roller used to counter – react the gear meshing separation forces between a rack and pinion

3.25

automatic brake

a device to decelerate and stop moving parts in case of interruption of the power supply

3.26

buffer

a resilient stop at the end of the travel, comprising a means of arresting using fluids, springs or similar means

3.27

overspeed

any speed above rated speed

3.28

safety gear

a mechanical device for stopping and maintaining the work platform stationary on the mast in the event of
overspeed

3.29

overspeed governor

a device which, when the work platform attains a predetermined speed above rated speed, causes the safety
gear to be applied

3.30

competent person

a person having such practical and theoretical knowledge and such experience of that MCWP as is necessary
to carry out the function satisfactorily

3.31

user (user organisation)

the person or organisation which has direct control over the MCWP use

Figure 1 — Typical single mast MCWP

Figure 2 — Typical twin mast MCWP

4 List of hazards

The list of hazards according to the following tables are based on #EN ISO 12100$ and Directive 89/392/EEC as amended by 91/368/EEC and 93/44/EEC.
Tables 1.1, 1.2 and 1.3 show the hazards which have been identified and where the corresponding requirements have been formulated in this standard in order to limit the risk or reduce these hazards in each
situation.
A hazard which is not applicable or is not significant and for which, therefore, no requirements are formulated,

is shown in the relevant clauses column as NA (not applicable).

Table 1.1 — List of hazards (part 1)

HAZARDS	RELEVANT CLAUSES IN THIS STANDARD
1 Mechanical hazards (caused for example by:	
1.1 Crushing	5.2.1.3; 5.3.2; 5.4.1
1.2 Shearing	5.2.1.3; 5.3.2; 5.4.1
1.3 Cutting or severing	5.3.2; 5.4.1
1.4 Entanglement	5.4.1
1.5 Drawing-in or trapping	5.2.1.3; 5.3.2; 5.4.1
1.6 Impact	5.4.4
1.7 Stabbing or puncture	NA
1.8 Friction or abrasion	NA
1.9 High pressure fluid ejection	5.9.7; 5.9.8; 5.9.9; 5.9.10
1.10 Ejection of parts	5.2.1.4; 5.2.1.5
1.11 Loss of stability	5.1.5; 5.2.2.4; 5.2.2.5
1.12 Slip, trip and fall	5.2.2.1; 5.3.1
2 Electrical hazards	
2.1 Electrical contact	5.8; 7.1.2.7
2.2 Electrostatic phenomena	NA
2.3 Thermal radiation	NA
2.4 External influences	5.7.15 Annex C
3 Thermal hazards	**Relevant but not dealt with**
4 Hazards generated by noise	**Relevant but not dealt with**
5 Hazards generated by vibration	5.1.2.3.2
6 Hazards generated by radiation	NA
7 Hazards generated by materials and substances processed, used or exhausted by machinery:	
7.1 Contact with or inhalation of harmful fluids, gases, mists, fumes and dusts	5.9
7.2 Fire or explosion	NA
7.3 Biological and microbiological	NA
8 Hazards generated by neglecting ergonomic principles in machine design:	

(continued)

Table 1.1 — List of hazards (part 1) (concluded)

HAZARDS	RELEVANT CLAUSES IN THIS STANDARD
8.1 Unhealthy postures or excessive efforts	5.2.1.6; 5.2.5.2; 5.6.2; 5.12; 5.12.8
8.2 Inadequate consideration of human hand/arm or foot/leg anatomy	NA

8.4 Inadequate area lighting 7.1.2.6
8.5 Mental overload or underload, stress NA
8.6 Human error 5.2.2.1; 5.12

9 Hazard combinations 5.1.1.1; 5.1.1.2; 5.1.3

10 Hazards caused by failure of energy supply,

breaking down of machinery parts and other

functional disorders

5.1

10.1 Failure of energy supply 5.2.2.1; 5.6; 5.8.1.4; 5.12.7
10.2 Unexpected ejection of machine parts or fluids 5.9.7; 5.9.8; 5.9.9; 5.9.10
10.3 Failure or malfunction of control system 5.2.1.5
10.4 Errors of fitting 5.1.5.1.5
10.5 Overturn, unexpected loss of machine stability 5.1.1.2; 5.1.5; 5.7

11 Hazards caused by missing and/or incorrectly

positioned safety related measures/means

8.3 Neglected use of personal protection equipment 5.12.8; 7.1.2.7; 7.1.2.12
11.1 Guards
11.2 Safety related (protection) devices 5.7
11.3 Starting and stopping devices 5.1.1; 5.3.4.9; 5.12
11.4 Safety signs and signals 5.2.2.7; 7.1.2.9
11.5 Information or warning devices 7.1.2.9
11.6 Energy supply disconnecting devices 5.2.1.2; 5.8.1.2
11.7 Emergency devices 5.5; 5.6
11.8 Feeding/removal means of workpieces NA
11.9 Essential equipment and accessories for safe adjusting
and/or maintaining
5.2.3.1; 5.4.2.10
11.10 Equipment evacuating gases NA

Table 1.2 — List of hazards (part 2)

HAZARDS RELEVANT CLAUSES IN THIS STANDARD

12 Inadequate lighting of moving/working area

(continued)

7.1.2.6

13 Hazards due to sudden movement instability etc

during handling

5.1.5; 5.2.2.1; 5.2.2.3; 5.2.2.4; 5.4.3

14 Inadequate/non-ergonomic design of operating

position

14.1 Hazards due to dangerous environments (contact with
moving parts, exhaust gases etc)
5.2.2
14.2 Inadequate visibility from operators position 5.12.2; 5.12.5
14.3 Inadequate seat/seating NA
14.4 Inadequate/non-ergonomic design/positioning of controls 5.12

14.5 Starting/moving of self-propelled machinery 5.12
14.6 Road traffic of self-propelled machinery 7.1.2.6; 7.1.2.12
14.7 Movement of pedestrian controlled machinery 7.1.2.6; 7.1.2.12

15 Mechanical hazards 5.1.1.1

15.1 Hazards to exposed persons due to uncontrolled movement
5.2.2.1; 5.2.4; 5.3.1.5, 5.4.1; 7.1.2.7
15.2 Hazards due to break-up and/or ejection of parts 5.2.1.4; 5.2.1.5; 5.2.2.3
15.3 Hazards due to rolling over (ROPS) 5.1.5
15.4 Hazards due to falling objects (FOPS) 7.1.2.7
15.5 Inadequate means of access 5.3.3; 5.3.4
15.6 Hazards due to towing, coupling, connecting, transmission etc
5.2.2.6
15.7 Hazards due to batteries, fire, emissions etc NA

16 Hazards due to lifting operations

16.1 Lack of stability 5.1.5; 5.1.1.2; 5.2.2.4; 5.2.2.5; 5.2.5.1
16.2 Derailment of machinery 5.2.2.4; 5.4.1.5; 5.4.2
16.3 Loss of mechanical strength of machinery and lifting accessories
5.1; 5.2.1.7; 5.2.1.8; 5.2.2.2; 5.2.2.3; 5.2.3.2; 5.2.3.3; 5.2.5.2; 5.2.5.3; 5.3.1.4; 5.4.2; 5.4.3
16.4 Hazards caused by uncontrolled movement 5.2.2.5; 5.2.4; 5.4.1; 5.11

17 Inadequate view of trajectories of the moving parts 5.12

18 Hazards caused by lightning 7.1.2

19 Hazards due to loading/overloading 5.7

Table 1.3 — List of hazards (part 3)

Hazards according to the second amendment to the Machinery Directive involving the lifting of persons by
MCWP.

HAZARDS RELEVANT CLAUSES IN THIS STANDARD

20 Overloading or overcrowding of the carrier 5.1.2; 5.7; 5.10 Annex C

21 Unexpected movement of the carrier in response to external controls or other movements of the machine

5.12.7

22 Excess speed 5.4.1; 5.5; 5.6.3

23 Persons falling from the carrier 5.3

24 The carrier falling or overturning 5.2.2.3; 5.4.1; 5.5; 5.10; 5.11

25 Excess acceleration or braking of the carrier 5.2.2.4; 5.4.3.1.2; 5.4.4

26 Due to imprecise markings 5.2.2.7; 7.2

5 Safety requirements and/or measures

5.1 Structural and stability calculations

5.1.1 General

5.1.1.1 All loads and forces which can occur in any allowed configuration during erection, operation, out-ofservice,
dismantling and transfer shall be considered. This shall also include inclined or hanging masts.

5.1.1.2 The manufacturer shall be responsible for:

- Stability calculations, in order to identify the various configurations of the MCWP and the combinations of
loads and deflections, which together create conditions of instability;
- Structural calculations, to evaluate the individual forces and to make allowance for deflections. All combinations of forces shall be considered including those which produce the most unfavourable stresses
in the components.

5.1.2 Loads and forces

The following loads and forces shall be taken into account:

5.1.2.1 Structural loads

The masses of the components of the MCWP when they are not moving are considered to be static structural
loads.
The masses of the components of the MCWP when they are moving are considered to be dynamic structural
loads.

5.1.2.2 Rated load

5.1.2.2.1 The rated load for design purposes is:

$m = (n \cdot m_p) + T + (2 \times m_e)$
where m = rated load (kg)
m_p
= 80 kg; mass of each person
m_e
= 40 kg; mass of personal equipment (for the first two persons only)
T = mass (kg) of material and equipment on the work platform (excluding personal equipment)
n = number of persons on the work platform
The mass of persons and the mass of equipment and material shall act simultaneously.
The minimum number of persons shall be:
Two (2) for single mast platforms and four (4) for multiple mast platforms.
The mass of the personal equipment (m_e) shall be assumed to act on the point coincident with each of the two
persons which give the highest stresses.

5.1.2.2.2 The mass of each person is assumed to act as a point load on the MCWP at a horizontal distance
0,1 m from the upper inside edge of the top guard rail. The distance between the point loads shall be 0,5 m
(see figure 3 as an example).

5.1.2.2.3 The mass T shall be evenly distributed over the whole area of the main platform giving a specific
load per length t.
The centre of gravity of the mass T shall be assumed to act on a point 0,15 B (where B is the width of the

main platform) away from the longitudinal centre line of the main platform, on the side giving the highest
stresses. See figure 4.
Calculations must allow for the possibility that a reduced load giving an unbalanced loadcase may result in
higher stresses in some parts of the MCWP than a balanced rated load case would give.
For single mast machines the bending moment, M, on masts and platforms shall be calculated according to
formula 1, where L_{max} is the greater of the distances L_1 and L_2 in figure 5.
For multiple mast machines the bending moment M, on masts and platforms shall be calculated according to
formulas 2, 3, 4 and figure 6. The factors 1,15 and 1,2 are used in the formulas 1, 2, 3, 4 in order to cover the
situations in use where, instead of a uniformly distributed load, a concentration of the same load is placed
elsewhere within that individual length.

Dimensions in metres

Figure 3 — Example of the distribution of persons on the main platform or platform extensions

Figure 4 — Eccentric loading normal to the centre line

Specific load $t = \frac{L}{T}$

Formula (1): $M_{max} = \frac{2}{2} \cdot 1{,}15 \cdot {}_{max}t \cdot L \cdot$

Figure 5 — Loading in the longitudinal direction. Single mast machines

Specific load $t = \frac{L}{T}$

Formulas:

(2) $M_1 = \frac{2}{2} \cdot 1{,}15 \cdot {}_1t \cdot L \cdot$

(3) $M_2 = \frac{8}{2} \cdot 1{,}2 \cdot {}_2t \cdot L \cdot$

(4) $M_3 = \frac{2}{}$

2 1,15
3 $t \cdot L \cdot$

Figure 6 — Loading in the longitudinal direction. Multiple mast machines

5.1.2.2.4 If the area of the main platform, or part of it, is increased by means of extensions, usually to the longitudinal edge of the platform, the mass of the number of persons allowed on the platform, according to 5.1.2.2.1, shall be assumed to act on these longitudinal edges according to 5.1.2.2.2.

5.1.2.2.5 In order to provide long cantilever extensions of restricted width to reach more distant work points an exception to 5.1.2.2.4 may be made, but shall be clearly explained on a sign easily visible on that particular extension to the main platform. In no such case shall the load on the extension be calculated for less than two persons (m_p) carrying their personal equipment (m_e). In order to restrict the available platform extension area, such extensions shall not be more than 0,6 m wide. See Figure 7.

-

Dimensions in metres

Key

1 main platform
2 platform-extension

Figure 7 — Long cantilever extensions™

5.1.2.2.6 Where the manufacturer includes in his design, provision for the use of a handling crane then the mass of the crane and the crane's rated load shall together be treated as part of the rated load of the MCWP.
The location of the force resulting from the use of the crane shall be dictated by the manufacturer's chosen mounting positions for the crane supports.

5.1.2.3 Horizontal forces

5.1.2.3.1 Manual forces

The minimum value for the manual force is assumed to be 200 N for each of the first two persons on the platform and 100 N for each additional person permitted to be on the work platform.
It is assumed that the force is applied at a height of 1,1 m above the floor of the work platform and acts in a horizontal direction.

5.1.2.3.2 Forces from the use of power tools

Where the manufacturer of the MCWP permits the use of power tools which impose horizontal reaction forces

on the work platform which are in excess of those given in 5.1.2.3.1 then the manufacturer shall specify the
maximum force permitted. It is to be assumed that the force is applied at a minimum height of 1,1 m above the
floor of the work platform.
Such forces may be caused by the use of, for example:
- Water jetting equipment;
- Sand or grit blasting equipment;
- Mechanically assisted drilling machine;
- Hammer assisted drill;
- Electrically driven hammer/breaker.

5.1.2.3.3 Forces from the use of weather protection screens on the Work Platform

If the Work Platform is designed to permit the use of weather protection, in the form of a roof over part of, or
the whole of a work platform, then the resulting wind forces shall be considered to act on walls which reach
the full height from the work platform floor to the top of the roof. Wind forces shall be calculated according to
5.1.2.5 and 5.1.2.8. For platform regions protected by such weather screens, the wind forces on persons,
equipment and material coming under the protection of these weatherscreens may be neglected.
The mass of the weather protection screens shall be treated as part of the rated load.

5.1.2.4 Dynamic forces

Dynamic forces shall be taken into account by multiplying all moving masses by a dynamic factor of 1,15.
Moving, includes the raising and lowering of the work platform and also transfer of the MCWP in its transfer
condition.

5.1.2.5 In service wind loads

5.1.2.5.1 All MCWP used out-of-doors or otherwise exposed to wind, whilst in service, shall be regarded as
being affected by a minimum wind pressure in accordance with table 2.

Table 2 — Minimum design wind data, in service

Installation	Wind velocity [m/s]	Wind pressure [N/m2]
Freestanding or MCWP during erection and dismantling	12,7	100
Tied MCWP	15,5	150

5.1.2.5.2 Wind forces are assumed to act horizontally at the centre of the wind area of the exposed structural parts of the MCWP.

5.1.2.5.3 The windforce coefficients applied to areas exposed to the wind shall be in accordance with ISO 4302. The windforce coefficient for persons exposed to the wind is 1,0.

5.1.2.5.4 The full area of one person is 0,7 m_2 (0,4 m average width · 1,75 m height) with the centre of
area 1,0 m above the work platform floor.

5.1.2.5.5 The exposed area of one person standing on a work platform behind an imperforate section of
fencing 1,1 m high is 0,35 m_2 with the centre of area 1,45 m above the work platform floor.

5.1.2.5.6 The number of persons directly exposed to the wind is calculated as:

a) The length of the side of the work platform exposed to the wind, rounded to the nearest 0,5 m and divided
by 0,5 m, or
b) The number of persons allowed on the work platform if less than the number calculated in a).

5.1.2.5.7 If the number of persons permitted on the work platform is greater than in 5.1.2.5.6 a), a reducing
coefficient of 0,6 may be applied to the extra number of persons.

5.1.2.5.8 The wind force on exposed equipment and material on the work platform is calculated as 3 % of
the mass (T), acting horizontally at a height of 1,0 m above the work platform floor.

5.1.2.6 Loads and forces occurring during transfer conditions

Inertia forces plus any load permitted by the manufacturer on the work platform shall be taken into account
when the MCWP is subject to transfer conditions.

5.1.2.7 Erection and dismantling loads

The load for which the MCWP has been designed during erection and dismantling. Erection load may be
higher than rated load.
If the handling crane, as carried in 5.1.2.2.6, is used during erection and dismantling of the MCWP, then the
crane's mass and the rated load shall together be treated as part of the erection load.

5.1.2.8 Out of service wind loads

Whilst out of service, with the work platform in a safe position, the wind pressure for the calculations shall be
in accordance with table 3.
The limiting wind pressure shall be considered in the most unfavourable direction.

Table 3 — Design wind pressures, out of service

Height of member above ground level (m)	Wind Velocity (m/s)	Wind Pressure {N/m2)
0 to 20	35,8	800
over 20 to 100	42	1100
over 100	45,9	1300

NOTE The wind values given in table 3 are minimum values for the central European area and at low altitudes. In
special cases, e.g. coastal areas or at higher altitudes, information set out in specific national standards shall be used
until relevant European standards are available.

5.1.2.9 Buffer zones

Buffer forces shall be calculated taking into account the characteristics of the buffer.

5.1.2.10 Action of the safety means according to 5.5

To determine the forces produced by an operation of these means, the sum total of all travelling masses shall
be multiplied by a factor of 2. A lower factor, but not less than 1,2 may be used if it can be verified by test
under all conditions of loading up to 1,5 times the rated load.

5.1.2.11 Inaccuracies in setting up

For the purposes of calculation an allowance of an additional 0,5° shall be made to allow for user inaccuracy
when erecting the mast.

5.1.3 Load combinations and safety factors

The load combinations to be taken into consideration shall be as follows:
Load combination A1: MCWP in service without wind, static.
Load combination A2: MCWP in service without wind, dynamic.
Load combination B1: MCWP in service with wind, static.
Load combination B2: MCWP in service with wind, dynamic.
Load combination B3: MCWP during erection or dismantling.
Load combination B4: MCWP during transfer condition.
Load combination C1: MCWP striking the buffer whilst in service.
Load combination C2: MCWP during action of the safety means whilst in service.
Load combination C3: MCWP out of service.

The above load combination references (A1, A2, B1, B2 etc) are used in Annex A (informative) as load case
A, load case B and load case C as appropriate.
In each load combination the loads and forces acting on the MCWP shall be in accordance with table 4.
Safety factors for structural steels and aluminium alloys are given in Table 5 and Table 6 respectively.

Table 4 — Load combinations that shall be taken into consideration

Load combination Loads Ref. clause	A1	A2	B1	B2	B3	B4	C1	C2	C3
Structural loads 5.1.2.1	X	X	X	X	X	X	X	X	X
Rated load 5.1.2.2	X	X	X	X	X	X			
Horizontal forces 5.1.2.3	X	X							
Dynamic forces 5.1.2.4	X	X	X	X					
In service wind loads 5.1.2.5	X	X	X	X					
Loads and forces during transfer condition 5.1.2.6	X	X							
Erection and dismantling loads 5.1.2.7	X								
Out of service wind loads 5.1.2.8	X								
Buffer forces 5.1.2.9	X								
Action of safety means 5.1.2.10	X								
Inaccuracies in setting up 5.1.2.11	X	X	X	X	X	X			

Table 5 — Safety factors for structural steels

Load case	Safety factor

A1, A2 1,5
B1, B2, B3, B4 1,33
C1, C2, C3 1,25

Table 6 — Safety factors for structural aluminium alloys

Load case Safety factor
A1, A2 1,7
B1, B2, B3, B4 1,55
C1, C2, C3 1,4

5.1.4 Structural calculations

See Annex A (informative).

5.1.5 Stability calculations

5.1.5.1 Calculation of forces

5.1.5.1.1 Forces causing overturning moments shall, when created by structural masses, be multiplied by a factor of 1,1 and when created by rated loads be multiplied by a factor of 1,2. It must be remembered here that an inclination of mast from the vertical will result in an increasing overturning moment as the work platform travels upwards.
All forces causing stabilizing moments shall be multiplied by a factor of 1,0.

5.1.5.1.2 Wind forces shall be multiplied by a factor of 1,2 and assumed to be acting horizontally.

5.1.5.1.3 Horizontal forces as detailed in clause 5.1.2.3 shall be multiplied by a factor of 1,2 and assumed to be acting in the direction creating the greatest overturning moment.

5.1.5.1.4 Forces according to 5.1.2.6 shall be treated in the same way as specified in 5.1.5.1.1, 5.1.5.1.2 and 5.1.5.1.3 as appropriate.

5.1.5.1.5 Inaccuracies in setting-up according to 5.1.2.11 shall be taken into account in the stability calculation.

5.1.5.2 Calculation of overturning and stabilizing moments

5.1.5.2.1 The maximum overturning and corresponding stabilizing moments shall be calculated about the most unfavourable tipping lines.
The calculations shall be made with the MCWP in the most unfavourable configurations with the maximum allowable inclination of the chassis defined by the manufacturer. Every load and force combination including inaccuracy in setting-up shall be taken into account in their most unfavourable combinations.
In each case the calculated stabilizing moment shall be greater than the calculated overturning moment.

5.2 General machine requirements, base frame, chassis and mast

5.2.1 General machine requirements

5.2.1.1 The MCWP and all parts belonging to it shall be calculated in accordance with 5.1.

5.2.1.2 MCWP shall be equipped with a permanently installed device on the work platform to switch off the
work platform and secure it against unauthorised use whilst out of service.
Similar devices shall be permanently installed at the chassis of self-propelled MCWP which isolates all
movements of the MCWP.
Such devices shall be secured by a pad-lock or similar device.

5.2.1.3 Trapping and shearing points between the chassis and work platform shall be avoided by providing
safe clearances or adequate guarding. See EN 349 and EN 953. !When it is foreseen (e.g. for maintenance) that the fixed guard will be removed regularly then the fastenings shall remain attached to the
guard or to the machinery."
If safe clearance or adequate guarding is not possible, then an acoustic warning device shall be fitted to the
work platform which at least gives a continuous warning when the work platform is moving within 2,5 m of the
chassis.
Trapping, crushing and shearing points need only be considered at those areas within reach of persons on the
work platform or standing adjacent to the MCWP at ground level, or at other points of access.

5.2.1.4 Locking pins shall be designed to be mechanically secured against unintentional disengagement
and loss, e.g. split pin, locking nut whilst in position. In addition, they shall be provided with means to secure
against unintentional loss when out of use e.g. captive chain.

5.2.1.5 Where compression springs are used for a safety function they shall be guided with secured ends.
Their design shall be such that if they break then the parts cannot coil into each other.

5.2.1.6 The design of all components that have to be handled during erection e.g. mast sections, platform
components, erection cranes, shall have their mass assessed against manual handling. Where the permissible mass for normal handling, is exceeded, the manufacturer shall give recommendations in the
instruction handbook concerning suitable lifting equipment.

5.2.1.7 Attachment of lifting equipment

Where components are erected by means of lifting equipment, provision shall be made for adequate attachment of the lifting equipment. This shall ensure that the component is securely attached and lifted in the
correct attitude for assembly.

5.2.1.8 Lifting equipment

Any dedicated lifting equipment shall be designed in accordance with ISO 8686-1 and ISO 4301-1 and shall
not impose loads on the MCWP structure for which the MCWP was not designed.

5.2.2 Base frame and chassis

5.2.2.1 General

If chains or belts are used in drive systems, inadvertent movements of the chassis shall be automatically
prevented if failure of a chain or belt occurs.

If powered and manual drive systems are provided for the same movement, interlocks shall prevent both
systems from being engaged at the same time.
After failure of the power supply, no inadvertent movement shall occur.
Walkways on the base frame or chassis shall be equipped with a slip resistant surface.

5.2.2.2 Base frame

The base frame shall be equipped with fixings for safe and secure attachment of other parts of the construction such as mast and outriggers.

5.2.2.3 Chassis

The chassis shall be equipped with fixings for safe and secure attachment of other parts of the construction
such as mast and outriggers.
Means shall be provided to ensure, or at least give proper warning, that the MCWP is in the proper transfer (or
transport) condition.
If the platform must be locked at a position on the chassis during transport, then transport interlocks shall be
provided.
Means shall be provided to prevent instability of the MCWP due to failure of any tyre of the chassis, for
example by the provision of foam filled tyres or by giving instructions in the user manual regarding use of
outriggers.

5.2.2.4 Drive to wheels (excluding road transport)

The chassis shall be capable of being stopped and held stationary with a braking device under all ground
conditions and also the worst combination of horizontal speed and maximum gradient specified by the
manufacturer. The brakes shall only be released and kept released by an intended action. Under all conditions
the brake shall apply automatically. After being applied the means of braking shall not depend on an exhaustible energy source.
Acceleration and retardation must be within the manufacturer's stability criteria. It shall be possible to disengage the drive to the wheels before towing the MCWP.
For rail mounted chassis, means shall be provided to stop the machine safely at the limits of travel.
If axles are detachable, the chassis shall be equipped with fixings for safe and secure attachment of the axles
when they are in use.

5.2.2.5 Outriggers

Outriggers shall be capable of carrying all loads permitted by the manufacturer. Max. allowable inclination and
operation on the max. gradient permitted by the manufacturer shall also be considered.
The feet of the outriggers shall be designed to swivel in all directions by an amount equal to the maximum
gradient specified by the manufacturer plus at least 10°.
A notice on the outriggers shall refer the user to the instruction handbook for information on the applied
ground pressure resulting from the outrigger feet.
Movement of the outrigger beams shall be limited by mechanical stops. It shall also be possible to lock them
at least in their extreme positions.

The outriggers shall be designed and manufactured so that unintentional movement is prevented. Any hydraulic outrigger shall be equipped with a load holding valve, mounted directly to the cylinder. This valve, e.g. a pilot operated check valve or brake valve, shall prevent unintended flow of oil to or from the cylinder, even in case of pipe or hose rupture. The closing of this valve shall not cause a dangerous situation.

Power operated outriggers shall be fitted with a device to prevent power operated movement of the outriggers unless the work platform is in its intended position.

Outriggers relying on a permanent pneumatic pressure to provide support during use of the platform shall not be used.

Where central supports are provided directly beneath the masts these shall also comply with the relevant requirements of this clause.

5.2.2.6 Towbar

If towbars, when not in use, are left in a raised position, an automatic device shall be provided to hold the towbar in this position. Unintentional release shall not be possible.

Towbar and steering mechanisms shall be designed to prevent handling hazards to the user.

5.2.2.7 Warning marks

Outriggers, outrigger beams and other parts of the base frame or chassis protruding from the main outline of the platform shall be marked with warning colours.

5.2.3 Mast structure

5.2.3.1 General

Detailed examination of the rack and its means of attachment shall be possible without dismantling.

5.2.3.2 Racks

The racks shall be securely attached to the mast. Joints between adjacent sections of the rack shall be accurately aligned to avoid faulty meshing or damage to teeth.

5.2.3.3 Tie attachment points

If the MCWP is to be tied into a separate supporting structure the mast sections shall be designed to accommodate the attachment of ties at appropriate intervals. Attachment points shall be designed in accordance with 5.1.

5.2.3.4 Marking

All mast sections shall be marked with an individual identification or serial number enabling the date of manufacture to be determined.

5.2.4 Mast design with regard to erection

Effective means shall be provided to ensure, so far as practicable, that only correctly interchangeable mast sections can be connected together.

The design of the mast shall ensure effective load transfer between adjacent mast sections and that alignment is maintained.

Where the vertical members of the mast sections are used as guides for drive frame guide rollers the joints of
adjacent sections shall provide a continuous path.
MCWP with masts which are tilted to the working position for use shall be equipped with a device to ensure
that the mast is mechanically locked in the working position automatically. It shall not be possible to raise the
work platform unless this lock is engaged.

5.2.5 Mast ties

5.2.5.1 General

MCWP's will require lateral restraint from an adjoining separate supporting structure when erected above the
manufacturer's specified maximum free standing height. This restraint will normally be in the form of mast ties
attached at intervals between the mast and the supporting structure.

5.2.5.2 Design

Mast ties shall be designed for manual handling and ease of assembly using hand tools and shall provide a
degree of adjustment to accommodate tolerances between the MCWP mast and the supporting structure.
They shall provide sufficient torsional rigidity to the mast.

5.2.5.3 Attachment to the supporting structure

The attachment of the mast ties to the supporting structure shall be designed to resist all forces generated,
both in and out of service.
Sufficient information shall be provided in the instruction handbook to enable the forces applied to the
supporting structure to be calculated.

5.3 Work platform

5.3.1 General

5.3.1.1 The work platform shall remain in a horizontal position within + 2° during normal movements of the
platform and under the application of the rated load and other forces exerted during normal operation. During
operation of the means described in 5.5 and the emergency lowering/raising device in 5.6 the max permitted
variation from horizontal shall be + 5°.

5.3.1.2 Trapdoors in the work platform shall be securely fastened and shall not open downwards.

5.3.1.3 The floor material shall be slip-resistant. The floor shall be easy to clean and shall be self-draining.
Any opening in the floor or between the floor and toeguards or access gates shall be dimensioned so as to
prevent the passage of a sphere of 15 mm diameter. The floor material shall be securely fixed to the work
platform. Any extensions shall be prepared for fixing of the floor material.

5.3.1.4 The work platform floor shall be designed to withstand without permanent deformation a static load
of at least 200 kg exerted on the least favourable square area of 0,1 · 0,1 m.

5.3.1.5 Any telescopic extensions of the main platform shall be able to be secured to prevent their inadvertent movement. There shall be a clear indication of the maximum permitted extended position.

5.3.1.6 Platform extensions shall not be more than 0,5 m above or below the level of the main platform.

5.3.2 Guarding

!

5.3.2.1 All sides of the main platform and any platform extension shall be designed to be equipped with a
guardrail and toeboards which can be securely fastened in position.

5.3.2.2 With the exception of a side erected towards a wall (see 5.3.2.3 and Table 8), all sides of the platform or any extension shall be equipped with guardrails at least 1,1 m high with an intermediate guardrail
not more than 0,5 m from the top guardrail or from the toeboard and toeboards 0,15 m high.

5.3.2.3 Guarding the side erected towards a wall depends on the horizontal distance (gap) between the
platform and the wall. The following options shall be provided for use in accordance with 7.1.2.12 Figure 9 and
Table 8.
1) 1,1 m high guardrail in accordance with 5.3.2.2;
2) 0,7 m high guardrail (without intermediate rail but with toeboard);
3) 0,15 m high toeboard.

5.3.2.4 The guardrails shall be constructed to withstand concentrated forces of 300 N for each person
permitted on the platform, applied in the outwards horizontal direction at 0,5 m intervals.
The top of each guardrail shall also be constructed to withstand a single vertical load of 100 kg applied in the
least favourable position but not simultaneously with the horizontal load."

5.3.2.5 Chains or ropes shall not be used as guardrails.

5.3.2.6 Those sides of the main platform and any extensions immediately adjacent to the mast shall be
protected to a height of at least 2 m to prevent access to the mast. Apertures shall comply with EN 294.

5.3.2.7 If extensions of the work platform are positioned between the mast and the building, then means
shall be provided to prevent travel of the work platform with the extension in place.

5.3.2.8 Where the platform extension is not flush with the main platform, the unprotected opening between
the two levels shall be guarded at least with a toeboard of 0,15 m height located on the lower level.
#

5.3.2.9 When it is foreseen (e.g. maintenance) that the fixed guard rails will be removed regularly then the
fastenings shall remain attached to the guard rail segments or to the platform.$

5.3.3 Access

5.3.3.1 At least one access gate shall be provided and it shall not open outwards. All access gates shall be
so constructed as to either close automatically or be electrically interlocked to prevent operation of the work

platform unless they are closed. Inadvertent opening of the access gate shall not be possible. Chains or ropes
shall not be used as access gates.

5.3.3.2 When the distance between the access level and the floor of the work platform in the access position exceeds 0,5 m, the MCWP shall be equipped with an access ladder or stairs symmetrical with the
access gate. The steps or rungs shall be divided equally over the distance between the access level and the
floor of the work platform and in no case shall the step rise be more than 0,3 m.

The front of the steps or rungs shall be located to give at least 0,15 toe clearance.

5.3.3.3 Handholds, handrails or similar adequate devices shall be provided to facilitate climbing the access
ladder to the work platform.

5.3.4 Multilevel work platforms

5.3.4.1 For multilevel work platforms the special requirements as set down in Annex B for options A and B
shall be taken into account. In addition the following shall apply.

5.3.4.2 All additional components that are used with multilevel MCWP shall be calculated according to 5.1.
All additional forces imposed upon the main platform and the mast structure shall be calculated according to
5.1.

5.3.4.3 Guarding shall be in accordance with 5.3.2

5.3.4.4 Roof protection shall be arranged for the lowest platform in option B to protect persons from falling
objects.
The roof construction for the lowest platform shall:

- Be designed to withstand a load of 100 kg distributed on any area 0,1 m · 0,1 m
- Be designed so as to prevent the passage of a sphere of 15 mm diameter.

5.3.4.5 In option A the two work platforms shall not be separated by more than 3 m between platform floor
levels.

5.3.4.6 The separation distance between work platforms in option B shall be controlled by safety contact
switches. This distance shall not be less than 2,5 m in normal operation taking into account levelling inaccuracies.

5.3.4.7 Ladders for option A shall comply with 5.3.3. Fixed access between the two work platforms shall be
provided within the platform guarded area. Trapdoors shall comply with 5.3.1.2.
For option B direct access between work platforms shall not be provided.

5.3.4.8 For option A with multiple mast applications, platform levelling shall be in accordance with 5.3.1.1.
The design shall ensure that clearance remains between the subsidiary work platform and the mast over the
full levelling range.

5.3.4.9 Controls shall be in accordance with 5.12.

5.3.4.10 Buffers shall be in accordance with 5.4.4. For option A where the subsidiary work platform is located below the primary work platform, the height of the buffer shall be increased in order to act on the
primary work platform.

5.3.4.11 For option A travel limit switches shall be in accordance with 5.11 taking into account the position of
the subsidiary work platform.
For option B separate travel limit switches shall be provided for each work platform, all in accordance with
5.11 making allowance for the separation distance required in 5.3.4.6.

5.4 Drive systems for elevation

5.4.1 General

5.4.1.1 The maximum rated speed when raising and lowering the platform shall be no more than 0,2 m/s.

5.4.1.2 Fixed guarding shall be provided to prevent the entry of any material that might cause damage to
any part of the drive system and to protect persons from injury. #When it is foreseen (e.g. for maintenance)
that the fixed guard will be removed regularly then the fastenings shall remain attached to the guard or to the
machinery.$

5.4.1.3 Chains or belts shall only be used in drive mechanisms in conjunction with an electrical safety
device which stops the work platform and keeps it stopped as soon as failure of a chain or belt occurs.

5.4.1.4 Manual drive systems shall be designed and constructed to prevent kick-back of handles.

5.4.1.5 Measures shall be taken to prevent the uppermost guide rollers or shoes running off the top of the
guides during normal operation. Further measures shall be taken to ensure that under no circumstances
including erection and dismantling, can any safety device pinion come out of mesh with the rack.

5.4.1.6 Measures shall be taken to ensure the continued stability of the work platform in the case of failure
of any guide roller.

5.4.1.7 Any hydraulic drive shall conform to EN 982. In addition the applicable requirements in 5.9 shall
apply.

5.4.2 Rack and pinion system

5.4.2.1 Means shall be provided to maintain the rack and the driving or any safety gear pinion constantly in
mesh under all conditions of load. Such means shall not rely upon the platform guide rollers. The devices
used shall restrict movement of the pinion on its axis such that at least two-thirds of the tooth is always in
engagement with the rack.

5.4.2.2 In addition it shall not be possible for the pinion to move out of its correct engagement with the rack
by more than one third of the tooth height, even in the event of failure of a counter roller or other mesh control
feature or local bending or deflection of the mast.

5.4.2.3 The rack and pinion tooth model shall not be less than

| Four (4) for drive systems where the counter roller or other mesh control feature reacts directly on the
rack without the interposition of any other mast profiles.
| Six (6) where the reaction of the counter roller or other mesh control feature is by means of another element of the mast which is then in immediate contact with the rack.

5.4.2.4 Any safety gear pinion shall be situated lower than the drive pinions.

5.4.2.5 The drive pinion shall be designed according to ISO 6336, regarding tooth-strength, for a minimum
of 10^8 load-cycles. The pinion shall be so dimensioned that, based on ISO 6336-5, there shall exist a minimum safety factor of 1,5 for tooth-strength taking into account the actual stress induced in the teeth under
the total suspended static load per pinion.

5.4.2.6 The rack shall be made from material having properties matching those of the pinion in terms of
wear and shall be designed according to ISO 6336, regarding tooth-strength, for a minimum of 10^4 load-cycles
representing static strength.
The rack shall be so dimensioned that based on ISO 6336-5, there shall exist a minimum safety factor of 1,5
for tooth-strength for the actual stress induced in the teeth.

5.4.2.7 When more than one drive pinion is meshing with the rack, it shall only be permissible to share the
design loads between the pinions, if a self-adjusting measure is provided to guarantee load sharing under all
normal running conditions.
For drive systems according to 5.5.1.1 b) load sharing shall be neglected, and calculation of the rack and the
pinion shall be in accordance with 5.5.3 g).

5.4.2.8 A pinion shall never be used as a guide roller.

5.4.2.9 Visual examination of all the pinions shall be possible without removal of the pinions or major disassembly of structural components of the MCWP.

5.4.3 Braking systems

5.4.3.1 General requirements

5.4.3.1.1 Every work platform shall be provided with a brake system which operates automatically:
a) In the event of loss of the main power supply;
b) In the event of loss of the supply to control circuits.
If two or more masts are used there shall be a braking ability for each mast.
The braking system shall have at least one electro-mechanical brake (friction type) or hydro-mechanical
brake, but may, in addition, have other braking means (e.g. electric).

Belts or chains for coupling the drive pinion to the component on which the brake operates are not permitted.

5.4.3.1.2 The brake(s) on its own shall be capable of stopping the platform, travelling at rated speed and
with 1,25 times the rated load with a retardation between 0,2 and 1,0 g. In addition the brake(s) on its own
shall be capable of stopping the machine when travelling at the triggering speed of the overspeed governor
with the rated load.

5.4.3.1.3 In the case of only one brake, all the mechanical components of the brake which take part in the
application of the braking action on the drum or disc or drive pinion shall be constructed and installed in such
a way that if a failure in one of them occurs sufficient braking shall remain to bring the work platform with rated
load to a stop.

5.4.3.1.4 The components on which the brake operates shall be positively coupled to a sprocket or drive
pinion.

5.4.3.1.5 Any machine fitted with an emergency lowering or raising device according to 5.6 shall be capable
of having the brake released manually and require a constant effort to keep the brake open.

5.4.3.1.6 The action of the brake shall be exerted by compression springs. The springs shall be adequately
supported and shall not be stressed in excess of 80 % of the torsional elastic limit of the material.

5.4.3.1.7 Brake blocks and linings shall be of incombustible material (the use of asbestos is forbidden) and
shall be so secured that normal wear does not weaken their fixings.
Brakes shall be provided with means of adjustment.
Brake blocks and linings shall be protected against ingress of lubricants, water, dust or other contaminants to
at least IP 23 (see EN 60529).

5.4.3.1.8 Band brakes shall not be used.

5.4.3.2 Special requirements for electro-mechanical brakes

5.4.3.2.1 In normal operation, a continuous flow of current shall be required to hold off the brake.
The interruption of this current shall be effected by at least two independent electrical devices, whether or not
integral with those which cause interruption of the power supply of the drive motor.
If, when the work platform is stationary, one of the contactors has not opened the main contacts, further
movement shall be prevented at the latest at the next change in the direction of motion.

5.4.3.2.2 When the motor of the work platform is likely to function as a generator, it shall not be possible for
the electric device operating the brake to be fed by the driving motor.
Braking shall become effective without delay after opening of the brake release circuit (the use of a diode or
capacitor connected directly to the terminals of the brake coils shall not be considered as a means of delay).

5.4.3.3 Special requirements for hydro-mechanical brakes

5.4.3.3.1 In normal operation a continuous oil pressure shall be required to hold off the brake.

5.4.3.3.2 When the motion of the platform is initiated, the brake shall not reach the hold off position before
the normal operating torque for the drive is attained.

5.4.4 Buffers

5.4.4.1 MCWP shall be provided with buffers at the bottom limit of the travel of the work platform.

5.4.4.2 The total possible stroke of the buffer(s) shall be at least equal to the stopping distance corresponding with, the work platform with rated load, being arrested by the buffers from its maximum
possible speed at a deceleration of 1,0 g. The maximum possible speed to be considered shall be that which
can occur in service or the tripping speed of the overspeed governor whichever is the greater.

5.4.4.3 If the buffers travel with the work platform they shall strike against a clearly recognizable pedestal.

5.5 Means to prevent the work platform from falling with overspeed

5.5.1 General

5.5.1.1 All MCWPs shall be equipped with a device, or means which prevents the work platform from falling
in the event of any failure (other than a structural failure of the mast/work platform) and which operates before
a speed of 0,5 m/s is exceeded. This device, or means, shall automatically arrest and sustain the work
platform with 1,1 · the rated load.
These devices or means shall, when tripped, cause a deceleration not less than 0,05 g and not more than
1,0 g.

This shall be achieved by one of the following systems:
a) A safety gear;
or
b) Two or more independent and identical electric motor direct drive units fitted to each mast.

5.5.1.2 Adjustable components which have a safety related function shall either require tools for their adjustment or be capable of being sealed against unauthorised adjustment.

5.5.1.3 These devices or means shall be designed to ensure that environmental conditions cannot affect
their safe operation.

5.5.2 Safety gear and overspeed governor

5.5.2.1 Safety gear

The safety gear specified in 5.5.1.1 a) shall:
a) Be independent of the drive machinery other than the rack;
b) Be always fully operational in normal use, erecting, maintenance and dismantling;
c) Not be dependent on energizing or maintaining an electrical or other auxiliary circuit;
d) Be accessible for inspection, maintenance and testing without major dismantling;
e) Be designed using a safety factor of 2,5 based on the ultimate strength of the material and the highest
force which can occur in the device with rated load and max. possible speed (see 5.5.1.1);

f) Be able to be tested by a competent person remote from the work platform so that persons are not exposed to danger;
g) Not use any part of the safety gear for guidance of the work platform;
h) Positively actuate on the masts or racks and shall be tripped by an overspeed governor (see 5.5.2.2);
i) Be designed so that all control circuits for normal operation will be automatically interrupted by a safety
switch before or at the time the safety gear is applied;
j) Be designed so that the method of release of the safety device will require the intervention of a competent
person in order to return the MCWP to normal operation;
k) Be designed such that the braking effect of the safety gear shall increase progressively from the point of
tripping of the overspeed governor to the point of bringing the platform to rest.

5.5.2.2 Overspeed governor

5.5.2.2.1 The overspeed governor shall trip at a speed defined by the manufacturer, but in no case shall the
work platform exceed the speed stated in 5.5.1.1.

5.5.2.2.2 Overspeed governors shall operate mechanically and shall either be driven by the safety gear
pinion or by rope.

5.5.2.2.3 If ropes and pulleys are used for overspeed governors

- The rope diameter shall not be less than 6 mm;
- The ratio between the diameters of the ropes and the rope pulleys shall not be less than 20;
- The ratio between the highest pull force which could occur in the rope and the minimum breaking force of
the rope shall not be less than 8;
- The minimum generated force shall not be less than 300 N and not less than twice the force necessary to
engage the safety gear.

5.5.3 System involving two or more drive units fitted to each mast

The system specified in 5.5.1.1 b) shall:
a) Have at least 2 drive units fitted to each mast where each drive unit shall have its own brake, with each
brake unit being completely independent and each being positively but separately connected to the rack
and pinion system.
b) Be such that each brake on its own shall be capable of stopping and sustaining the work platform when
carrying 1,1 · rated load, from the max possible speed even under emergency lowering conditions (see
5.6);
c) Be always fully operational in normal use, erection, maintenance and dismantling;
d) Be able to be tested by a competent person such that each individual brake can be tested separately;
e) Be accessible for inspection, maintenance and functional testing of the system without major dismantling;
f) When activated, interrupt automatically the control circuit for normal use;
g) Have each drive unit designed using a safety factor of 2,5 based on the ultimate strength of the material

and the highest force which can occur in the drive with rated load and max. possible speed;
h) Be designed and manufactured in accordance with 5.10 where appropriate;
i) Detect malfunctions in each drive unit which endanger proper function. These shall at least indicate a loss
of mechanical integrity which results in a differential in the current demand between each drive unit, exceeding 25 % of the full load current;
j) Have each individual drive unit fitted with a mechanical device that automatically prevents the work platform exceeding 0,4 m/s descent speed. Each such speed limiting device, when acting on its own, shall be capable of carrying the work platform and its rated load in the most disadvantageous configuration. Each device shall also be designed using a safety factor of at least 2,5 based on the basic
ultimate strength of the material and the highest force which can occur.

5.6 Means for emergency lowering and raising the work platform

5.6.1 The MCWP shall be fitted with means which permit the manually controlled emergency lowering of the
work platform under certain circumstances. Such circumstances shall include electrical failures but may
exclude those mechanical failures which would prevent the safe movement of the work platform. It is intended that such means shall offer the possibility of the emergency lowering of the work platform such
that persons can leave it, dependent upon suitable site conditions being available.

5.6.2 The means shall:

a) Be operated from a safe, but easily accessible location on the work platform which also permits the best
possible view of the travel area;
b) Have controls which are adequately shrouded or otherwise arranged to prevent, as far as possible,
accidental operation from any cause;
c) Only be operable by a hold-to-run control which permits lowering of the work platform only as long as the
control is manually held in a set position;
d) The manual force required on the control shall be no more than 400 N;
e) Require the temporary release of the braking system (see 5.4.3);
f) Permit the immediate automatic re-application of the braking system upon release of the emergency
lowering controls;
g) Permit lowering whilst the work platform is carrying 1,1 · rated load;
h) Allow that no part of the work platform shall exceed + 5° from the horizontal, according to 5.3.1.1 during
emergency lowering.

5.6.3 The emergency lowering means shall not prevent the operation of the devices according to 5.5.1.1 a)
and 5.5.3 j);

5.6.4 Means for emergency raising of the work platform may be fitted in addition to the means for emergency lowering. When fitted, the emergency raising means shall comply with 5.6.1 as well as 5.6.3 with
the word raising substituted for lowering in all cases.

5.7 Overload/moment device

5.7.1 The MCWP shall be provided with an overload and moment detecting and indicating device. For
exception see 5.7.16.

5.7.2 This device shall detect the total load due to persons, equipment and materials on the work platform. It
shall also detect those moments due to these loads, that are likely to lead to overturning or failure of the
MCWP. This device shall at least detect:

- Bending and torque moments on cantilevered main platforms;
- Bending and torque moments on the central part of simply supported main platforms;
- Bending moment on the mast.

5.7.3 Overload moment detection device shall be carried out at least whilst the work platform is stationary.

5.7.4 The overload/moment detector shall be consistent with the rated loads and their location shown or
described on the rated load chart(s) for the MCWP.

5.7.5 The load and moment detection and indication shall function

a) Automatically for the different possible platform configurations;
or

b) If automatic detection and indication are not possible for different configurations, then a work platform
configuration selector shall be provided which allows a clear classification of the chosen setting in comparison with actual work platform configuration. This can be done by either:
1) A clear sign of the respective platform configuration
or
2) A code at each setting. In this case a clear reference shall be given to the explanation of the code on
a separate code or configuration sign.

5.7.6 The number of possible selections permitting use of the work platform shall not exceed the number of
configurations for the work platform.

5.7.7 The selector shall be so situated or protected so as to be inaccessible to unauthorised persons.

5.7.8 The overload/moment detector shall be triggered before reaching a load/moment of 1,1 x rated load/moment and once triggered shall continuously isolate the controls concerned until the overload/moment
has been removed.

5.7.9 The design and installation of overload/moment detectors and indicators shall take into account the
need to test the MCWP with overloads without dismantling and without affecting the performance of the
detector or indicator.

5.7.10 The overload/moment indicator shall continuously, visually and audibly, warn the operator and other
persons in the vicinity of the work platform when the overload/moment detector is activated.

5.7.11 No provision shall be made for the user to cancel the warning.

5.7.12 Visual warnings shall be positioned to be in full view of persons on the work platform.

5.7.13 The overload/moment detector and indicator shall be arranged so that their operation (but not necessarily their accuracy) can be checked without applying loads to the work platform.

5.7.14 The overload/moment detector and indicator shall comply with 5.10.

5.7.15 The electrical and electronic requirements for overload detection devices are given in Annex C.

5.7.16 Devices according to 5.7.1 to 5.7.15 are not required if the following demands are met:
All design calculations shall be based on the loads m_D, m_e and T that are related to the rated load 'm' in
5.1.2.2.1 increased by a further factor f as a function of 'm' according to figure 8.

Key
f factor
m rated load in kg

Figure 8

Brakes and safety devices/means shall be calculated with the same loads as mentioned in the first paragraph.
For stability calculations the increased loads shall be considered in case they give overturning moments.

5.8 Electrical systems

5.8.1 General

5.8.1.1 Electrical and electronic installations and their appliances shall be in accordance with EN 60204-1,
which applies in full.

5.8.1.2 At the chassis or base there shall be mounted a main switch according to EN 60204-1 at an easily
accessible position.

5.8.1.3 Any drive system shall have, within a distance of not more than 2 m from the drive, a supply disconnecting device able to separate the energy supply from the drive in all poles of phases.

5.8.1.4 Safety and control circuits shall be in accordance with EN 60204-1. The safety and control circuits
shall be electrically separated from all other circuits.

5.8.1.5 Transformers shall be used for supplying control circuits. Such transformers shall have separate
winding and one side of the control circuit shall be connected to the protective bonding circuit (PE) (see 8.4
and 9.1.1 of EN 60204-1:1992).

5.8.1.6 All safety contacts shall be of positive opening operation type complying with the requirements of
EN 60947-5-1.

5.8.1.7 In the event of a failure of one phase of the supply to the directional control device, the machine
shall stop.

5.8.1.8 Precautions shall be taken to ensure the free and safe movement of any trailing cable throughout
the full range of travel of the work platform. Where the mast is inclined or where multilevel work platforms to

option B (annex B) are used, additional precautions are necessary, for example by making the cable follow the
incline of the mast by the use of guides or the use of automatic cable reeling drums.

5.8.2 Safety switches

The operation of a safety switch shall be by positive separation of the contacts, even if the contacts have been
welded together. Safety switches shall comply with 5.8.1.6 and the conditions set out in table 7 below.

Table 7 — Conditions for use of electric switches

Clause Devices checked Switch EN 954-1 Category of control system
5.3.4.6 Separation distance switch sc 1
5.5.2.1 i) Operation of overspeed safety devices sc 1
5.11.1 Terminal stopping switch ssr B
5.11.2 Final limit switch sc 1

Abbreviations:
ssr = safety switch, self-resetting
sc = safety switch in a safety circuit

5.8.3 Control system

The control system shall comply with EN 954-1 category 1 unless otherwise stated in table 7. This includes
any control system using electrical or hydraulic power.
In redundancy-type circuits and diversity-type circuits measures shall be taken to limit as far as possible the
risk of defects occurring simultaneously in more than one circuit arising from a single cause.

5.9 Hydraulic system

5.9.1 The hydraulic system shall be designed so that the safety requirements for fluid power systems and
components in EN 982 are met.

5.9.2 It shall be the responsibility of manufacturers to determine by calculations and test the working pressures which can occur in any part of the circuits.

5.9.3 Each hydraulic circuit shall be provided with a connection for a pressure gauge.

5.9.4 The design of the hydraulic system shall enable trapped air to be vented.

5.9.5 Any hydraulic tank open to atmosphere shall be equipped with an air breathing filter.

5.9.6 Each hydraulic tank shall be equipped with a device indicating the fluid level and marked with the
maximum and the minimum level.

5.9.7 The hydraulic system shall be fitted with a pressure relief valve in order to provide protection against
excess pressure. It shall be adjustable, sealed and designed so that the setting shall only be possible with the
aid of special tools. The valve shall be adjusted for a pressure which is no more than 20 % above the pressure

in operation with the rated load. If different maximum pressures are used in the hydraulic system then a
corresponding number of pressure relief valves shall be provided.

5.9.8 Pressurised parts of the hydraulic system which may be subjected to the maximum pressure permitted
by the pressure relief valve shall be designed to withstand at least twice that pressure without permanent
deformation.

5.9.9 The bursting pressure of hoses, including fittings, which may be subjected to the maximum pressure
permitted by the pressure relief valve shall be not less than four times that pressure.

5.9.10 All other parts of the hydraulic system shall be designed to withstand at least the maximum pressure to
which they will be subjected.

5.9.11 Pilot operated control valves shall be so designed and installed that they fail to safety in the event of
power failure.

5.10 Special requirements for safety devices, depending on auxiliary circuits and for overload/moment devices

5.10.1 The device shall be compatible with the designed use of the MCWP.

5.10.2 Devices shall be in accordance with EN 60204-1. Systems shall enable periodic functional checks to
be carried out to verify that all functions are operating correctly.

5.10.3 If interruption of the power occurs, all data and calibration of the indicators shall be retained.

5.10.4 Limiting and indicating device systems shall fail to a "safe" condition, in which any fault results in a
shutdown of the control circuits for normal operation.

5.11 Travel limit switches

5.11.1 Terminal stopping switches with contacts according to chapter 3 of EN 60947-5-1:1991 shall be
provided and positioned so that they automatically stop the work platform from rated speed at the highest and
lowest levels. At the lowest level, initiation of stopping should occur before contact with the buffer and before
contact with the final limit switch. At the highest level, initiation of stopping shall occur before contact with the
final limit switch.

5.11.2 An upper final limit switch shall be provided. It shall be positioned such that the work platform will
come to a complete stop before reaching the top of the mast. After triggering the upper final limit switch,
downward movement of the work platform may be permitted but no further upward movements shall be
possible until corrective action has been taken by a competent person.
A lower final limit switch shall be provided. It shall interrupt the electric supply such that the work platform is

not powered into the buffers. After triggering the lower final limit switch all movements of the work platform
shall be prevented until corrective action has been taken by a competent person.

5.11.3 Separately mounted actuating and control devices shall be used for the terminal stopping (travel limit)
switches and the final limit switches.
It is permitted to have one final limit switch to serve both the upper and lower limit switch functions.

5.12 Controls

5.12.1 On self-propelled MCWP it shall not be possible to operate the horizontal and vertical movement for
the transfer controls simultaneously.

5.12.2 The control device for normal vertical movement shall be situated on the work platform only. The
control device for horizontal movement of the MCWP-chassis shall not be situated on the platform.

5.12.3 If movement can be controlled from different control positions, the controls shall be interlocked in such
a way that control is only possible from one pre-selected control position.

5.12.4 Platforms shall be provided with hand operated controls such that all movements of the platforms can
only take place whilst the control is being actuated. When released, the controls shall automatically return to
the neutral position. All controls shall be arranged to prevent inadvertent operation.

5.12.5 Whilst moving the platform vertically the positioning of the control station has to be arranged in a way
to provide the operator with the best possible view of the travel area and to ensure safe movement of the
platform. A warning sign shall be mounted on any movable station stating that vertical operation of the work
platform from places other than the work platform itself is forbidden.

5.12.6 Emergency stop controls shall be arranged on the platform in accordance with EN 60204-1.

5.12.7 On starting, or restoration of the power after failure of the power supply, no further movement shall
occur without the intervention of the operator.

5.12.8 Controls shall conform to EN 614-1 whilst taking into account the possibility of the operator wearing
gloves.

6 Verification of the safety requirements and/or measures

6.1 Examinations and tests for each new model of MCWP

6.1.1 Design check

The design check shall verify that the MCWP is designed in accordance with this standard. It will include inter
alia the check of the following documents:

a) Drawings containing the main dimensions of the MCWP;
b) Description of the MCWP with necessary information about its capabilities;
c) Information about the materials used;
d) Diagrams of the electrical, hydraulic and pneumatic circuits;

e) Operating instructions.
The above documents shall give all necessary information to enable
- The stability calculations to be checked (see 5.1.5)
- The structural calculations to be checked (see 5.1.4)

6.1.2 Practical tests

Practical tests shall be made to verify that
- The MCWP is stable;
- The MCWP is structurally sound;
- All functions work correctly and safely.

These tests shall be made:
a) In the case of a freestanding MCWP, with the mast erected to its maximum freestanding height;
b) In the case of a tied-in MCWP, with at least two ties in position at their maximum permitted spacings with
maximum permitted top overhang.
MCWPs which are capable of operating in both freestanding and tied-in conditions shall be tested in both
configurations.

6.1.2.1 Stability tests

6.1.2.1.1 The MCWP shall be set up on the maximum allowable inclination of the chassis defined by the
manufacturer plus 0,5° with outriggers (if fitted) used as specified by the manufacturer. Test loads shall be
applied to represent all the most unfavourable load and force combinations specified in 5.1.5.
The test may be carried out on level ground if the test loads are recalculated to include the effects of the
maximum allowable inclination of the chassis defined by the manufacturer plus 0,5°.
The test loads may be applied at any suitable strong point, if necessary, to avoid overstressing any part of the
MCWP.
The test is to be repeated in all the most unfavourable extended and/or retracted positions.
The untied MCWP is stable if it can come to a stationary condition without turning over while supporting the
test load and force combination(s).

6.1.2.2 Braking test of the chassis

All MCWPs fitted with wheeled chassis shall be subjected to a brake test with the unloaded platform in the
worst transfer condition. The brake must be able to stop and hold the MCWP in the worst transfer condition.
Application of the brake must not induce instability.

6.1.2.3 Overload test

The test load shall be 125 % of the rated load. All movements with the test loads shall be carried out at
accelerations and decelerations appropriate with safe control of the load.
When, due to the various combinations of loads or outreaches of a MCWP, tests with different test loads are
necessary, all movements shall be carried out with all test loads except where the most unfavourable conditions can be sufficiently simulated by one performance test.
During the overload test the test load shall be put into each position which creates maximum stress in any
load carrying part of the MCWP.

During the overload test the brakes shall be capable of stopping and sustaining the test load(s). After removing the test load(s) the MCWP shall show no permanent deformation.

The overload/moment device, if provided, shall be checked for compliance with 5.7.3 to 5.7.14.

6.1.2.4 Functional tests

6.1.2.4.1 General

Functional tests shall demonstrate that

- The MCWP can operate smoothly for all motions whilst carrying the rated load at the rated speeds;
- All safety devices work correctly;
- Maximum permitted speeds are not substantially exceeded.

6.1.2.4.2 Test of the systems to prevent the work platform from falling with overspeed according to 5.5.1.1. a) (safety gear)

Functional tests of the safety gear shall be carried out with the platform carrying 1,1 · the rated load. The work platform shall be allowed to overspeed to the governor tripping speed in order to determine that:
a) The overspeed device operates as specified by the designer, and
b) The safety gear is capable of arresting the motion of the work platform without the assistance of motor brakes and is within the designer's quoted stopping distance.

6.1.2.4.3 Test of the systems to prevent the work platform from falling with overspeed according to 5.5.1.1 b)

Functional tests of the independent drive units shall be carried out with the platform carrying 1,1 · the rated load. It shall be determined that:
a) The work platform can be stopped and sustained from rated speed by each of the drive units in turn by intentional release of the motorbrake of each one of the drive units in turn during the test;
b) The platform can be stopped and sustained from rated speed by intentional activation of the safety system according to 5.5.3 i);
c) In each case, the stopping distance is within the designer's quoted specification.

6.1.2.4.4 Test of the means for emergency lowering (and raising) of the work platform

a) For work platforms equipped with safety gear according to 5.5.1.1 a) check that the controls comply with 5.6.1 and 5.6.2 and that the work platform speed with 1,1 · rated load can be controlled according to the user instruction. Whilst lowering, permit the speed to increase further to the point where the safety gear operates, according to 5.6.3.
b) For work platforms equipped with means according to 5.5.1.1 b), check that the controls comply with 5.6.1 and 5.6.2 and that the lowering (and raising, if applicable) speed does not exceed 0,3 m/s with 1,1 · rated load on the work platform.

7 Information for use

7.1 Instruction handbook

7.1.1 Comprehensive information

Manufacturers or suppliers of MCWP shall supply in one of the official languages of the country where the
MCWP is to be used, sufficient comprehensive information for the safe use of the MCWP. #Presentation of
this information shall comply with Clause 6 of EN ISO 12100-2:2003.$

7.1.2 Content of the instruction handbook

The manufacturer and/or importer/supplier shall make available to the user an instruction handbook containing
at the least, information about the following topics:

7.1.2.1 General information

- Manufacturer's or supplier's name and address;
- Country of manufacture;
- Model designation;
- Serial or fabrication number;
- Year of manufacture;
- Vertical travel speed (m/s);
- Horizontal transfer speed (m/s);
- Outdoor/indoor installation;
- Maximum allowable freestanding height in and out of service (m);
- Maximum allowable wind speed during erection and dismantling (m/s);
- Maximum allowable wind speed in and out of service (m/s);
- Hydraulic supply information if an external hydraulic power supply is used;
- Pneumatic supply information if an external pneumatic power supply is used;
- Electrical supply information if an external electric power supply is used;
- Warning sign required regarding moveable control stations.

7.1.2.2 Capacity information

The following information shall be made available, both for MCWP with non-varying work platform configuration and for MCWP with varying work platform configurations. In the case of variable configuration
designs, the rated loads for particular main platform and platform extension configurations and any limitation
as to load distribution shall be displayed each time the MCWP is installed (see 7.2.3).

- Maximum platform dimensions (length x width including platform extensions);

- Rated load (kg);
- Maximum lifting height, untied mast (m);
- Maximum lifting height, tied mast (m);
- Tie distance (m);
- Top overhang in operation (m);
- Maximum permitted force applied to tools (manually or mechanically assisted) which is to be reacted by
the work platform;
- Maximum rated load on platform extensions (kg);
- Any load permitted on the work platform during transfer condition.

Sufficient information shall be given in the instruction handbook provided by the manufacturer such that the

owner can derive the particular details for each configuration. These particular details shall then be augmented by the name of the erection site and a reference to the relevant chapter in the instruction handbook, such that the user can display this load diagram on the MCWP.

7.1.2.3 Dimensions and weights

- Height from the ground to the work platform in its lowest position for access (m);
- Platform section: length · width · height (m);
- Platform section: weight (kg);
- Mast section: length · width · height (m);
- Mast section: weight (kg);
- Drive unit: length · width · height (m);
- Drive unit: weight (kg);
- Chassis: length · width · height (m);
- Chassis: weight (kg);
- Outrigger spread and configuration: length · width (m);
- Base unit (specified transport configuration): weight and dimensions length · width · height (m);
- MCWP installed by crane: weight (kg);
- MCWP installed by crane: max height of mast (m);
- Minimum area required for installation: length · width (m).

7.1.2.4 Electrical data

- Power – lifting machinery (kW);

- Power – transfer machinery (kW);
- Supply voltage/frequency (V/Hz);
- Control voltage/frequency (V/Hz);
- Maximum starting current (A);
- Maximum power consumption (kVA);
- Minimum power supply (kVA);
- Main power supply fuses and type (A);
- Outlets for portable tools – voltage and current (V, A).

7.1.2.5 Safety equipment

- Type of safety equipment (e.g. safety gear, terminal stopping switches and final limit switches);
- Additional safety equipment for erection and dismantling;
- Emergency lowering equipment.

7.1.2.6 Additional technical information

This shall include the following:

- Outrigger arrangements;
- Ground bearing pressure and the hazards associated with changing ground conditions;
- Tie arrangement and forces imposed on the supporting structure, for given wind zones;
- Freestanding arrangements for given wind speeds;
- Need for protection regarding hazardous areas around the MCWP;
- Provision of adequate lighting for safe operation;
- Precautions about platform extension between the building and the mast;
- Information regarding any lifting points;
- Consideration of the possible requirements for lightning protection.
- Consideration of the effects of any item which significantly increases the wind area (see 5.1.2.3.3);
- Consideration of any effects which significantly increase the wind speed e.g. adjacent tall buildings etc.;
- Where any non-standard configurations are required, these shall be agreed between the manufacturer,

the owner and the user, and information shall be added as an addendum to the instruction handbook;
| Transport procedure to and from site including the need for meeting the traffic regulations;
| Transfer of the MCWP around the site including maximum gradient;

| Instructions with regard to the use of slightly raised outriggers during transfer conditions in order to avoid
instability from, for instance, failure of one tyre.

7.1.2.7 Operation instructions

These shall include the following:
| Operating procedures including information on safe distances such as the clearance to power cables and
other overhead structures and between the platform and the building;
| Emergency procedures including the operation of safety devices, resetting by a competent person and
action to be taken in case of power loss, including the safe use of the means for emergency lowering.
This must include clear instructions regarding the safe lowering distance increments and any rest periods
needed in order to avoid the overheating of brake linings;
| That travelling controls cannot be operated with any other movement unless the MCWP is in transfer
condition;
| The use of relevant personal protective equipment such as hard hats, protective shoes, eye protection.

7.1.2.8 Operating personnel requirements

The instruction handbook shall state to the user the minimum requirements for the abilities of operating
personnel.

7.1.2.9 Operating procedure requirements

These shall include the following:
| Each day before the MCWP is taken into use, the user shall check the operating devices, brakes and
emergency stops. The condition of all trailing cables, travel limit switches, guardrails, structural connecting mast ties, cables and information plates shall also be checked;
| Keep the work platform clean from waste, building materials and of debris, snow etc.;
| Before any work is commenced, the operator shall visually check the outriggers and any timber or other
packing on the ground shall be visually checked to ensure that it is in good order;
| Ensure that tools and other objects do not project outside the perimeter of the MCWP;
| During the work the operator shall carefully follow the operation instructions;
| At the end of the work period the platform shall be brought into the "out of service" position and it shall be
isolated to prevent unauthorised operation;
| In the event of a fault with the MCWP, which can jeopardise safety, the operator shall immediately immobilise the MCWP and notify a responsible person;
| In case of emergency the operator must follow the relevant instruction in the user manual.

7.1.2.10 Maintenance instructions

These shall include the following:
| Schedule of regular maintenance together with required adjustments and tolerances and the required

intervals and personnel skill requirements:

| Information on precautions to be taken against hazards during maintenance;
| Regular replacement of specific parts including discard criteria;
| Information on the replacement of safety critical parts by identical components;
| Information into how to seal adjustable components which have safety related functions;
| Troubleshooting information;
| Electrical/Hydraulic/Pneumatic schematic diagrams;
| Parts lists/diagrams;
| List of maintenance work to be carried out only by specially trained persons together with a definition of
that training.

The manufacturer shall stress that regular maintenance shall include visual inspection and necessary
functional test and maintenance measures. Special attention shall be given to the inspection of load-bearing
parts with attachments, driving and stopping devices, operating and safety devices, racks and pinions etc.

7.1.2.11 Periodic examinations and test on MCWP

The instruction handbook shall state that the frequency and extent of periodic examinations and tests depends
on national regulations, manufacturer's requirements, operating conditions and the frequency of use. It is
normally not necessary to dismantle parts at periodic examinations, unless there are any doubts in relation to
reliability and safety. The removal of covers, the exposure of observation apertures, and bringing the MCWP
to the transport position are not considered to be dismantling.

The instruction handbook shall state the maximum time between periodic examinations and tests. Such
examinations and tests shall at least consist of the following:

| A visual examination of the structure with special attention to corrosion and other damage of load bearing
parts and welds
| An examination of the mechanical, hydraulic, pneumatic and electrical systems with special attention to
safety devices.

7.1.2.12 Instructions for erection and dismantling

These shall include the following:

| Detailed explanation of erection and dismantling procedure with special attention to mast assembly, mast
tie system, platform and extension assembly;
| Special hazards which can arise during erection and dismantling, with a description of any additional
safety equipment and how this may be used to reduce these hazards. The use of personal protective equipment shall be mentioned in this connection;
| Preparation of the site with special regard to the bearing capacity of the foundation, gantry, asphalt etc.
| Preparation of the site so that under no circumstances can instability occur during transfer of the equipment when using movable chassis;
| If platform travel must be limited due to obstructions in the travel path and the platform therefore does not

reach the normal limit switches, additional travel limit devices shall be installed to protect persons and
material on the platform or the platform itself from hazardous situations;

| Procedures to be observed when preparing the MCWP for transport shall be specified;
| If the MCWP can be loaded on a vehicle for transport or transfer suitable loading procedures must be
given;
| The clear gap between the ends of adjacent MCWP shall be not less than 0,5 m;
| Precautions shall be taken to ensure the free and safe movement of any trailing cable throughout the full
range of travel of the work platform. Where the mast is inclined or where multilevel work platforms to option B (annex B) are used, additional precautions are necessary, for example by making the cable follow the incline of the mast by the use of guides or the use of automatic cable reeling drums.
!Where the platform is erected towards a wall the instructions shall furthermore contain information regarding the required height (h) of guard rails on the work platform depending on the distance (d) between
the platform and the wall according to Figure 9 and Table 8. The instructions shall include specific information
to the user that it is very important to take into account the **local** use of the different guarding options in
relation to the distance that is **locally** existing between platform and wall face. Users are responsible for any
changes to, or removal of, guard rails in accordance with the legislation and possibly the working conditions in
force in the member state where the platform is erected."

Key

1 wall
2 guard rail
3 work platform

Figure 9

!Table 8 — Height of guard rails

d (m)	δ 0,25	0,25 < d δ 0,4	> 0,4
h (m)	0,15 c ε 0,7	b ε 1,1 a	

a with intermediate rail and toeboard according to 5.3.2.2
b without intermediate rail but with toeboard
c height of toeboard

Explanatory note to Table 8. The height "h" and the distance "d" has been chosen so as to avoid the risk of falling down
between the platform and the wall, avoid ergonomic hazards and also to limit or reduce the crushing or shearing risk
between the guard rail and wall obstacles when the platform is moving along the wall."

7.1.2.13 Examinations and tests after major alteration or major repairs to a MCWP already in use

Examination and test after major alterations or major repairs to MCWPs already in use shall consist of the

following
| Design check (see 6.1.1)
| Practical tests (see 6.1.2)
to an extent corresponding to the type of alteration of repair.
For the purpose of this European Standard "major alterations" are modifications of the whole or part of the
MCWP, which affect stability, strength of performance.

7.1.2.14 Check list

A list shall be provided in the instruction handbook which contains all safety relevant parts of the MCWP to be
checked after each erection. The result of the checks after each erection and the name and address of
person(s) making it shall be recorded in a signed report.

7.2 Marking

7.2.1 General

The manufacturer shall provide the following information on one or more durable signs or plates mounted in a
prominent place on the MCWP, in the official language of the country where the MCWP is to be used.

7.2.2 Information, non-varying

#
| The business name and the full address of the manufacturer or his authorised representative;$
| Country of manufacture;
| Model designation;
| Serial or fabrication number;
#
| the year of construction, that is the year in which the manufacturing process is completed;$
| Vertical travel speed (m/s);

| Transfer, travel speed (m/s);
| Out-/indoor installation;
| Maximum allowable freestanding height (m) in and out of service;
| Limiting windspeed during erection/dismantling;
| Maximum allowable windspeed in service/out of service [m/s];
| Hydraulic supply information if an external hydraulic power supply is used;
| Pneumatic supply information if an external pneumatic power supply is used.
| Electrical supply information if an external electric power supply is used;
| All guardrails to be in place at all times except for loading and unloading at the access level.

7.2.3 Information, varying

7.2.3.1 Capacity

A load diagram showing the rated loads for particular main platform and platform extension configurations and
any limitation as to load distribution. This shall be derived from the information presented by the manufacturer
according to 7.1.2.2.
The load diagram shall take the form of a durable sign or plate and shall be the responsibility of the user.
The manufacturer shall provide a means of mounting the load diagram.

7.2.3.2 Additional technical information

Outrigger arrangements and required ground bearing pressure.

Annex A

(informative)

Structural calculations

General

The calculations should conform to the rules and principles of applied mechanics and strength of materials. If
special formulae are used, the sources should be given, if they are generally available. Otherwise the
formulae should be developed from first principles, so that their validity can be checked.

A.1 In the absence of an EN-standard for design calculation the following guidelines may be used for the design of steel structures

A.1.1 Permissible stresses

Symbols f_y yield strength [N/mm2]
F_u ultimate strength [N/mm2]
E = 210 000 modulus of elasticity [N/mm2]
G = E/(2·(1+v)) shear modulus [N/mm2]
v = 0,3 Poissons ratio
$^{TM}{}_5$ elongation at failure on gauge length of 5 times
the diameter of the original cross section [%]
S Safety factor on yield strength

A.1.1.1 Non-alloy structural steels according to EN 10025

Table A.1 — Nominal values of material properties

Type	Yield Strength f_y [N/mm2] 1)	Ultimate Strength f_u [N/mm2] 2)
S235 (Fe360)	235	360
S275 (Fe430)	275	430
S355 (Fe510)	355	510

1) Standard value for smaller thickness
2) Minimum

A.1.1.1.1 Permissible stresses for non-alloy structural steels

$\sigma_0 = f_y/S$

Table A.2 — Permissible stresses for non-alloy structural steels (N/mm2)

Load case A B C
(N/mm2)
S 1,5 1,33 1,25
Steel grade 235 275 355 235 275 355 235 275 355
Basic material and butt weld
$\sigma_a = \sigma_0$ 157 183 237 176 206 266 188 220 284
$\tau_a = \sigma_0/\sqrt{3}$ 90 106 137 102 119 154 109 127 164
Fillet weld
$\sigma_a = \sigma_0$ 157 183 237 176 206 266 188 220 284
$\tau_a = \sigma_0/\sqrt{2}$ 111 130 167 125 146 188 133 156 201

The indicated permissible stresses are valid up to a thickness of 40 mm. In the case of larger thicknesses the
corresponding value of fy should be taken into consideration.
When selecting the materials special requirements should be taken into account, e.g.:

- Weldability;
- Use of the appliance in extreme climatic zones

A.1.1.2 Other steel grades

Depending on the minimum strength f_u and the elongation at failure δ_5 the following condition exists:
$510 < f_u \le 590$ $\delta_5 \cdot f_u \ge 10800$
$510 < f_u$ $\delta_5 \cdot f_u \ge 9800$
If these conditions are fulfilled the following applies: $f_y' = 0{,}8 \cdot f_u$.
If the conditions are not fulfilled, a reduced yield strength fy' should be defined with the factor r, which is
applied to the ultimate strength f_u:

$$r = \frac{9600}{2600\,(6)_5 + \delta_u f}$$

$1{,}28 \le r \le 1{,}44$

$$f_y' = \frac{r}{f_u}$$

Values of "r" to be used should be not less than 1,28 and not more than 1,44.

Based on the lower value of the yield strength f_y or f_y' the permissible stresses should be calculated with the
safety factors given for non-alloy structural steels.

A.1.1.3 Bolts

A.1.1.3.1 Black and fitted bolts

The permissible stresses are derived from X, which is the lower value of f_y and $0{,}7 \cdot f_u$.
$\sigma_a = X / S$ $\tau_a = \sigma_a/\sqrt{2}$

Table A.3 — Permissible stresses in bolts (N/mm2)

Grade 4.6 5.6 6.6 6.8 8.8 10.9
Load
case
S f_y 240 300 360 480 640 900
X 240 300 360 420 560 700

A 1,5 ∫a 160 200 240 280 373 467
| a 113 141 180 198 264 330
B 1,33 ∫a 180 225 270 315 420 525
| a 127 159 191 223 297 371
C 1,25 ∫a 192 240 288 336 448 560
| a 136 170 204 238 317 396

A.1.1.3.2 Preloaded bolts

Grade 8.8 and 10.9 only. Grade 12.9 may however be used if the conditions stated below are fulfilled. (See
Eurocode 3 – ENV 1993-1-1:1992).
Symbols
A_s tensile stress area of bolt [mm2]
F_v preload [N]
d nominal bolt diameter [mm]
M_t tightening torque [kNm]
Bolts used once $F_v = 0,8 \cdot f_y \cdot A_s$
Bolts used several times $F_v = 0,7 \cdot 0,8 \cdot f_y \cdot A_s$
Tightening torque

$$M_t = \frac{d \cdot F_v}{1000 \cdot 0,18}$$

The applied load F in relation to the preload F_v should be:
$F/Fv \le 0,67$ for load case A
$F/Fv \le 0,75$ for load case B

$F/Fv \le 0,8$ for load case C

A.1.1.3.3 Bearing pressure

The permissible bearing pressure ∫L depends on the basic material and is valid for bolted connections and
also for pins.
Loose connection $\int_L = 1,3 \cdot \int_0$
Low accuracy, fixed connection $\int_L = 1,5 \cdot \int_0$
High accuracy, fixed connection $\int_L = 2,0 \cdot \int_0$

Table A.4 — Permissible bearing pressure (N/mm2)

Load case A B C
Steel grade 235 275 355 235 275 355 235 275 355
Loose connection 204 238 308 229 268 346 244 286 369
Low accuracy, fixed connection 235 275 335 264 309 399 282 330 426
High accuracy, fixed connection 313 367 473 352 412 532 376 440 568

A.1.1.4 Combined stresses

Load carrying parts and butt welds:
$\int = \sqrt{\int_2 + \int_2 - \int \cdot \int + 3 \cdot |_{2xyxy}}$
Bolts, pin and fillet welds:
$\int = \sqrt{\int_2 + \int_2 - \int \cdot \int + 2 \cdot |_{2xyxy}}$

A.1.1.5 Elastic stability

A.1.1.5.1 Crippling

Symbols
λ slenderness
λ' specific slenderness
ω crippling factor
F compressive force [N]
A area [cm2]
M bending moment [Ncm]
W_c section modulus; compressive edge [cm3]
W_t section modulus; tensile edge [cm3]
σ_a permissible stress [N/cm2]

The crippling factor is defined in the following way:

$$\frac{E}{} \cdot f_y$$

$$\square$$

$$\lambda' \lambda$$

For $0 < \lambda' \leq 1{,}195$ (1 0,195 ' 0,185 '2.5

$$\frac{1}{\lambda \lambda}$$

$$\omega$$

$$\square \cdot \square \cdot$$

$$=$$

For $\lambda' > 1{,}195$ $\omega = 1{,}465\lambda'^2$

ω - factor already calculated for non-alloy structural steels see table A.5 to A.7.

The highest permitted slenderness is $\lambda = 250$.

The following conditions should be fulfilled:

$$\frac{\sigma_a}{}$$

$$\frac{W_c}{M}$$

$$\frac{}{A}$$

$$\omega \cdot F + 0{,}9 \cdot \delta \sigma$$

$$\frac{\sigma_a}{}$$

$$\frac{W_t}{M}$$

$$\frac{}{A}$$

$$\omega \cdot F + + \lambda \cdot \delta \sigma$$

$$\frac{1000}{300\ 2}$$

A.1.1.5.2 Buckling

Symbols
t thickness of plate [cm]
b width of plate [cm]
k factor depending on the stress conditions
σ_e Euler's buckling stress [N/mm2]
σ_{ki} ideal buckling stress [N/mm2]
σ_{vki} ideal combined buckling stress [N/mm2]
σ_{vk} reduced combined buckling stress [N/mm2]

σ_1 higher stress [N/mm2]
σ_2 lower stress [N/mm2]
$\sigma_{ki} = k\sigma \cdot \sigma_e$
$\tau_{ki} = k\tau \cdot \sigma_e$
$\psi = \sigma_1 / \sigma_2$
The reduced buckling stress σ_{vk} is defined in the following way.

$\sigma_{vki} < 0,7 \times f_y \quad \sigma_{vk} = \sigma_{vki}$
$\sigma_{vki} >= 0,7 \times f_y \quad \sigma_{vk} = \sigma_{vki} (1,4 - 0,4 \psi)$
1 0,461
σ_{vki} y
σ_{vk} y f
f
σ
$\sigma = \cdot$ □
The required minimum safety factor v depends on the load combination.
Load case A $v \geq 1,71 + 0,180 \cdot (\psi - 1,0)$
Load case B $v \geq 1,50 + 0,125 \cdot (\psi - 1,0)$
Load case C $v \geq 1,33 + 0,075 \cdot (\psi - 1,0)$
For further information refer to accepted buckling calculation methods.

A.1.2 Limit state method

The deflection of a structure should be taken into consideration when calculating the stresses. This is very
important when calculating a slender design or using materials with a low modulus of elasticity and can be
done by using the theory of the 2nd order. The safety factors against fy or fy' should be at least the following:
Load case A: $S \geq 1,50$
Load case B: $S \geq 1,33$
Load case C: $S \geq 1,25$

A.1.3 γ - values for non-alloy structural steels

Table A.5 — γ - values for S 235

S 235 yield strength f_y = 235 N/mm2

	0	1	2	3	4	5	6	7	8	9
20	1,05	1,05	1,05	1,06	1,06	1,06	1,07	1,07	1,07	1,08
30	1,08	1,08	1,09	1,09	1,10	1,10	1,10	1,11	1,11	1,11
40	1,12	1,12	1,12	1,13	1,14	1,14	1,14	1,15	1,16	1,16
50	1,17	1,17	1,18	1,18	1,19	1,19	1,20	1,21	1,21	1,22
60	1,23	1,23	1,24	1,25	1,26	1,26	1,27	1,28	1,29	1,30

70 1,31 1,31 1,32 1,33 1,34 1,35 1,36 1,37 1,39 1,40

80 1,41 1,42 1,43 1,45 1,46 1,47 1,49 1,50 1,52 1,53

90 1,55 1,56 1,58 1,60 1,61 1,63 1,65 1,67 1,69 1,71

100 1,74 1,76 1,78 1,81 1,83 1,86 1,89 1,92 1,95 1,98

110 2,01 2,05 2,08 2,12 2,16 2,20 2,24 2,27 2,31 2,35

120 2,39 2,43 2,47 2,51 2,55 2,60 2,64 2,68 2,72 2,76

130 2,81 2,85 2,89 2,94 2,98 3,03 3,07 3,12 3,16 3,21

140 3,26 3,30 3,35 3,40 3,44 3,49 3,54 3,59 3,64 3,69

150 3,74 3,79 3,84 3,89 3,94 3,99 4,04 4,09 4,15 4,20

160 4,25 4,31 4,36 4,41 4,47 4,52 4,58 4,63 4,69 4,74

170 4,80 4,86 4,91 4,97 5,03 5,09 5,15 5,20 5,26 5,32

180 5,38 5,44 5,50 5,56 5,62 5,69 5,75 5,81 5,87 5,93

190 6,00 6,06 6,12 6,19 6,25 6,32 6,38 6,45 6,51 6,58

200 6,64 6,71 6,78 6,85 6,91 6,98 7,05 7,12 7,19 7,26

210 7,33 7,40 7,47 7,54 7,61 7,68 7,75 7,82 7,89 7,97

220 8,04 8,11 8,19 8,26 8,33 8,41 8,48 8,56 8,63 8,71

230 8,79 8,86 8,94 9,02 9,10 9,17 9,25 9,33 9,41 9,49

240 9,57 9,65 9,73 9,81 9,89 9,97 10,05 10,13 10,22 10,30

Table A.6 — ⌉ - values for S 275

S 275 yield strength f_y = 275 N/mm2

⌊ 0 1 2 3 4 5 6 7 8 9

20 1,05 1,06 1,06 1,06 1,07 1,07 1,07 1,08 1,08 1,08

30 1,09 1,09 1,10 1,10 1,10 1,11 1,11 1,12 1,12 1,13

40 1,13 1,14 1,14 1,15 1,16 1,16 1,16 1,17 1,18 1,18

50 1,19 1,20 1,20 1,21 1,22 1,22 1,23 1,24 1,25 1,25

60 1,26 1,27 1,28 1,29 1,30 1,31 1,32 1,33 1,34 1,35

70 1,36 1,37 1,38 1,40 1,41 1,42 1,44 1,45 1,46 1,48

80 1,49 1,51 1,53 1,54 1,56 1,58 1,60 1,62 1,64 1,66

90 1,68 1,70 1,73 1,75 1,78 1,80 1,83 1,86 1,89 1,92

100 1,95 1,99 2,02 2,06 2,10 2,14 2,18 2,23 2,27 2,31

110 2,35 2,39 2,44 2,48 2,53 2,57 2,62 2,66 2,71 2,75

120 2,80 2,85 2,89 2,94 2,99 3,04 3,09 3,14 3,18 3,23

130 3,29 3,34 3,39 3,44 3,49 3,54 3,60 3,65 3,70 3,76

140 3,81 3,86 3,92 3,97 4,03 4,09 4,14 4,20 4,26 4,32

150 4,37 4,43 4,49 4,55 4,61 4,67 4,73 4,79 4,85 4,91

160 4,98 5,04 5,10 5,16 5,23 5,29 5,36 5,42 5,49 5,55

170 5,62 5,68 5,75 5,82 5,89 5,95 6,02 6,09 6,16 6,23

180 6,30 6,37 6,44 6,51 6,58 6,65 6,72 6,80 6,87 6,94

190 7,02 7,09 7,17 7,24 7,32 7,39 7,47 7,55 7,62 7,70

200 7,78 7,85 7,93 8,01 8,09 8,17 8,25 8,33 8,41 8,49

Table A.7 — ⌉ - values for S 355

S 355 yield strength f_y = 355 N/mm2

⌊	0	1	2	3	4	5	6	7	8	9
20	1,06	1,06	1,07	1,07	1,08	1,08	1,09	1,09	1,09	1,10
30	1,10	1,11	1,11	1,12	1,13	1,13	1,14	1,14	1,15	1,15
40	1,16	1,17	1,17	1,19	1,19	1,20	1,20	1,21	1,22	1,23
50	1,24	1,25	1,26	1,26	1,27	1,28	1,30	1,31	1,32	1,33
60	1,34	1,35	1,37	1,38	1,39	1,39	1,41	1,42	1,44	1,47
70	1,49	1,50	1,52	1,54	1,56	1,58	1,60	1,63	1,65	1,67
80	1,70	1,73	1,75	1,78	1,81	1,85	1,88	1,92	1,95	1,99
90	2,03	2,08	2,12	2,17	2,22	2,26	2,31	2,36	2,41	2,46
100	2,51	2,56	2,61	2,66	2,71	2,77	2,82	2,87	2,93	2,98
110	3,04	3,09	3,15	3,20	3,26	3,32	3,38	3,43	3,49	3,55
120	3,61	3,67	3,73	3,80	3,86	3,92	3,98	4,05	4,11	4,18
130	4,24	4,31	4,37	4,44	4,51	4,57	4,64	4,71	4,78	4,85
140	4,92	4,99	5,06	5,13	5,20	5,28	5,35	5,42	5,50	5,57
150	5,65	5,72	5,80	5,87	5,95	6,03	6,11	6,19	6,26	6,34
160	6,42	6,50	6,59	6,67	6,75	6,83	6,91	7,00	7,08	7,17
170	7,25	7,34	7,42	7,51	7,60	7,68	7,77	7,86	7,95	8,04
180	8,13	8,22	8,31	8,40	8,50	8,59	8,68	8,77	8,87	8,96
190	9,06	9,15	9,25	9,35	9,44	9,54	9,64	9,74	9,84	9,94
200	10,05	10,14	10,24	10,34	10,44	10,5	10,65	10,75	10,86	10,96
210	11,07	11,17	11,28	11,38	11,49	11,60	11,71	11,82	11,93	12,03
220	12,14	12,26	12,37	12,48	12,59	12,70	12,82	12,93	13,04	13,16
230	13,27	13,39	13,51	13,62	13,74	13,86	13,98	14,09	14,21	14,33
240	14,45	14,57	14,70	14,82	14,94	15,06	15,19	15,31	15,43	15,56

A.1.4 Analysis

A.1.4.1 General stress analysis

The general stress analysis is the proof against failure by yield or fracture. The analysis should be made for all
load bearing components and joints.

A.1.4.2 Elastic stability analysis

The elastic stability analysis is the proof against failure by elastic instability (e.g. buckling, crippling). The
analysis should be made for all load bearing components subjected to compressive loading.

A.1.4.3 Fatigue stress analysis

Only load case A has to be considered.
The fatigue stress analysis is the proof against failure by fatigue due to stress fluctuations. The analysis
should be made for all load bearing components and joints which are critical to fatigue taking into account the
constructional details, the degree of stress fluctuation and the number of stress cycles. The number of stress
cycles may be a multiple of the number of load cycles.
The number of load cycles for a MCWP is normally
$2 \times 10_4$ – intermittent duty (e.g. 10 years, 40 weeks per year, 25 hours per week, 2 cycles per hour).
It is permissible for the rated load to be multiplied by a load spectrum factor 0,5.
For further information refer to accepted fatigue stress analysis methods.

A.2 In the absence of an EN-standard for design calculations the following is applicable for the design of aluminium structures.

A.2.1 Permissible stresses

Symbols
f_y yield strength [N/mm2]
f_u ultimate strength [N/mm2]
E = 70 000 modulus of elasticity [N/mm2]
G = 27 000 shear modulus [N/mm2]
$^{TM}{}_5$ elongation at failure on gauge length of 5 times the diameter of the
original cross section [%]
S safety factor on yield strength
V safety factor on tensile strength

A.2.1.1 Standardised structural aluminium alloys

Table A.8 — Standardised aluminium alloys

Alloy No.	Alloy	Condition
1	AlZn4, 5Mg	11 F35
2	AlMgSi	1 F32
3	AlMgSi	1 F28
4	AlMgSi	0,5 F22
5	AlMg4,5Mn	G31
6	AlMg4,5Mn	W28
7	AlMg4,5Mn	F27
8	AlMg2Mn	0,8 F20
9	AlMg2Mn	0,8 F19
10	AlMg3	F18

A.2.1.1.1 Nominal values of material properties

Table A.9 — Properties of standardised aluminium alloys

Alloy No. Nominal thickness t of the element

t ≤ 10 mm

f_y [N/mm2] f_u [N/mm2]

1 275 350

2 255 315

3 200 275

4 160 215

5 205 310

6 125 275

7 125 275

8 100 200

9 80 180

10 80 180

A.2.1.1.2 Permissible stresses

$f_0 = f_y/S$ respectively f_u/V

$S_A \approx 1,7$; $V_A \approx 2,5$; $S_B \approx 1,55$; $V_B \approx 2,25$; $S_C \approx 1,4$; $V_C \approx 2,05$;

Table A.10 — Permissible stresses for standardised aluminium alloys in N/mm2

Load Case

A B C

Basic

Material

Welds Basic

Material

Welds Basic

Material

Welds

Alloy f_a | a f_a | a f_a | a f_a | a f_a | a f_a | a f_a | a f_a | a

1 160 95 75 60 180 110 85 70 200 120 90 80

2 145 90 55 40 165 100 60 45 180 110 65 50

3 115 70 55 40 130 80 60 45 110 90 65 40

4 95 55 35 25 105 60 40 30 115 65 45 30

5 120 70 55 45 135 80 65 40 150 90 70 55

6 70 45 55 45 80 50 65 50 90 55 70 55

7 70 45 55 45 80 50 65 50 90 55 70 55

8 55 35 35 30 65 40 40 35 70 45 45 40

9 45 30 35 30 50 35 40 35 55 40 45 40

10 45 30 35 30 50 35 40 35 55 40 45 40

When selecting the materials, special requirements should be taken into account, e.g.:
- condition after heat treatment and ageing;
- weldability;
- use of the appliance in extreme climatic zones;
- for other material characteristics consult national standards.

A.2.1.2 Combined stresses

Load bearing parts and butt welds:

$\sigma = \sigma_2 + \sigma_2 \cdot \sigma + 3 \cdot \tau_{xy} \tau_{xy}$

A.2.1.3 Elastic stability

Aluminium has a very low modulus of elasticity and a low shear modulus (~ 1/3 of the values of steel).
Therefore the problems with the elastic stability are much more obvious compared with steel structures.
Crippling, buckling, torsion buckling etc should be checked. Very slender constructions should be checked
according to the theory of the second order.

A.2.1.3.1 Crippling, omega method

Symbols
- λ slenderness
- ω crippling factor

ω - factors already calculated for aluminium see table A.11 to A.14.

A.2.1.3.2 Limit state method

The deflection of a construction should be taken into consideration when calculating the stresses. This is very
important when calculating a slender design or using materials with a low modulus of elasticity e.g. aluminium
and can be done by using the theory of the 2nd order. The safety factors against f_y or f_y' should be at least the
following:
Load case A $S \geq 1,7$
Load case B $S \geq 1,55$
Load case C $S \geq 1,4$

A.2.2 ω - values for aluminium alloys

The figures are valid for profiles but may also be used for tubes.

Table A.11 — ω - values for aluminium alloys 1 and 2

Alloy 1

yield strength f_y = 235 N/mm2

Alloy 2

yield strength f_y = 260 N/mm2

| 0 2 4 6 8 0 2 4 6 8

20 1,00 1,01 1,03 1,05 1,07 1,00 1,00 1,02 1,04 1,06

30 1,10 1,12 1,15 1,18 1,21 1,08 1,11 1,14 1,17 1,20

40 1,25 1,29 1,33 1,38 1,43 1,23 1,27 1,31 1,36 1,40

50 1,43 1,60 1,73 1,86 1,99 1,45 1,50 1,60 1,73 1,85

60 2,13 2,28 2,43 2,58 2,74 1,98 2,12 2,25 2,40 2,54

70 2,90 3,07 3,25 3,42 3,61 2,70 2,85 3,01 3,18 3,35

80 3,79 3,98 4,18 4,38 4,59 3,52 3,70 3,88 4,07 4,26

90 4,80 5,02 5,24 5,46 5,69 4,46 4,66 4,86 5,07 5,28

100 5,93 6,17 6,41 6,66 6,91 5,50 5,72 5,95 6,18 6,42

110 7,17 7,43 7,70 7,97 8,25 6,66 6,90 7,15 7,40 7,66

120 8,53 8,82 9,11 9,41 9,71 7,92 8,19 8,46 8,74 9,01

130 10,01 10,32 10,64 10,96 11,28 9,30 9,59 9,88 10,18 10,48

140 11,61 11,95 12,29 12,63 12,98 10,78 11,09 11,41 11,73 12,05

150 13,33 13,69 14,05 14,42 14,79 12,38 12,71 13,05 13,39 13,74

160 15,17 15,55 15,94 16,33 16,72 14,09 14,44 14,80 15,16 15,53

170 17,12 17,53 17,94 18,35 18,77 15,90 16,28 16,66 17,04 17,43

180 19,20 19,63 20,06 20,50 20,94 17,83 18,22 18,63 19,03 19,45

190 21,39 21,84 22,30 22,76 23,23 19,86 20,28 20,71 21,14 21,57

200 23,70 24,18 24,66 25,14 25,63 22,01 22,45 22,90 23,35 23,80

Table A.12 — ⌉ - values for aluminium alloys 3, 4 and 5

Alloy 3 and 5

yield strength f_y = 200 N/mm2

Alloy 4

yield strength f_y = 160 N/mm2

| 0 2 4 6 8 0 2 4 6 8

20 1,00 1,00 1,02 1,04 1,06 1,00 1,00 1,02 1,04 1,05

30 1,08 1,10 1,13 1,15 1,18 1,08 1,10 1,13 1,15 1,18

40 1,21 1,24 1,28 1,31 1,34 1,20 1,23 1,25 1,27 1,30

50 1,38 1,42 1,47 1,52 1,57 1,33 1,37 1,41 1,45 1,49

60 1,63 1,71 1,82 1,94 2,06 1,53 1,58 1,62 1,66 1,71

70 2,18 2,30 2,43 2,57 2,70 1,76 1,82 1,87 1,96 2,06

80 2,84 2,99 3,14 3,29 3,44 2,17 2,28 2,39 2,50 2,62

90 3,60 3,76 3,93 4,10 4,27 2,74 2,87 2,99 3,12 3,25

100 4,44 4,62 4,81 4,99 5,18 3,39 3,52 3,66 3,80 3,95

110 5,38 5,57 5,78 5,98 6,19 4,10 4,25 4,40 4,56 4,71

120 6,40 6,61 6,83 7,06 7,28 4,88 5,04 5,21 5,38 5,55

130 7,51 7,74 7,98 8,22 8,46 5,72 5,90 6,08 6,26 6,45

140 8,71 8,96 9,22 9,47 9,73 6,64 6,83 7,02 7,22 7,42

150 10,0 10,2 10,5 10,8 11,0 7,62 7,82 8,03 8,24 8,45

160 11,3 11,6 11,9 12,2 12,5 8,67 8,89 9,11 9,33 9,56

170 12,8 13,1 13,4 13,7 14,0 9,79 10,0 10,2 10,4 10,7

180 14,4 14,7 15,0 15,3 15,7 10,9 11,2 11,4 11,7 11,9

190 16,0 16,3 16,7 17,0 17,4 12,2 12,4 12,7 13,0 13,2

200 17,7 18,1 18,4 18,8 19,2 13,5 13,8 14,0 14,3 14,6

Table A.13 — ⌉ - values for aluminium alloys 6 and 7

Alloy 7 (profiles)

yield strength f_y = 140 N/mm2

Alloy 6 + 7 (profiles and box sections of sheet metal)

yield strength f_y = 125 N/mm2

⌊ **0 2 4 6 8 0 2 4 6 8**

20 1,00 1,00 1,01 1,03 1,05 1,00 1,00 1,01 1,03 1,05

30 1,07 1,09 1,11 1,14 1,16 1,07 1,09 1,11 1,14 1,16

40 1,19 1,21 1,24 1,27 1,30 1,19 1,21 1,24 1,26 1,29

50 1,33 1,35 1,38 1,42 1,45 1,32 1,35 1,38 1,41 1,44

60 1,49 1,53 1,57 1,61 1,65 1,47 1,51 1,55 1,58 1,62

70 1,70 1,75 1,80 1,85 1,90 1,66 1,70 1,75 1,79 1,84

80 1,96 2,01 2,09 2,19 2,29 1,88 1,93 1,98 2,03 2,08

90 2,40 2,51 2,62 2,73 2,85 2,14 2,24 2,34 2,44 2,55

100 2,96 3,08 3,20 3,33 3,46 2,65 2,75 2,87 2,98 3,09

110 3,59 3,72 3,85 3,99 4,13 3,21 3,32 3,44 3,57 3,69

120 4,27 4,41 4,56 4,70 4,85 3,82 3,94 4,07 4,21 4,34

130 5,01 5,18 5,32 5,48 5,64 4,48 4,62 4,76 4,90 5,05

140 5,81 5,97 6,14 6,32 6,49 5,19 5,34 5,50 5,65 5,82

150 6,67 6,85 7,03 7,21 7,40 5,96 6,12 6,28 6,45 6,62

160 7,58 7,78 7,97 8,16 8,36 6,78 6,95 ,713 7,30 7,48

170 8,56 8,77 8,97 9,18 9,39 7,66 7,84 8,02 8,21 8,40

180 9,60 9,81 10,0 10,2 10,4 8,59 8,78 8,97 9,17 9,37

190 10,7 10,9 11,1 11,3 11,6 9,57 9,77 9,97 10,1 10,3

200 11,8 12,0 12,3 12,5 12,8 10,6 10,8 11,0 12,2 11,4

BS EN 1495:1997+A2:2009

Table A.14 — ⌉ - values for aluminium alloys 8, 9 and 10

	Alloy 8					Alloy 9 + 10				
	yield strength f_y = 100 N/mm2					yield strength f_y = 80 N/mm2				
⌊	0	2	4	6	8	0	2	4	6	8
20	1,00	1,00	1,01	1,03	1,05	1,00	1,00	1,00	1,02	1,04
30	1,07	1,09	1,11	1,14	1,16	1,06	1,09	1,11	1,14	1,16
40	1,19	1,21	1,24	1,26	1,29	1,18	1,21	1,23	1,26	1,28
50	1,31	1,34	1,37	1,40	1,43	1,31	1,34	1,37	1,40	1,43
60	1,46	1,50	1,53	1,57	1,60	1,46	1,49	1,52	1,56	1,59
70	1,63	1,67	1,71	1,75	1,79	1,62	1,66	1,69	1,73	1,77
80	1,83	1,87	1,91	1,95	2,00	1,80	1,84	1,87	1,91	1,95
90	2,05	2,10	2,15	2,20	2,25	1,99	2,03	2,08	2,12	2,17
100	2,31	2,37	2,42	2,48	2,54	2,21	2,26	2,30	2,35	2,40
110	2,60	2,67	2,75	2,85	2,95	2,45	2,50	2,56	2,61	2,66
120	3,05	3,15	3,25	3,36	3,47	2,72	2,78	2,83	2,89	2,95
130	3,58	3,69	3,80	3,91	4,03	3,01	3,08	3,15	3,21	3,28
140	4,15	4,27	4,39	4,51	4,64	3,35	3,42	3,51	3,61	3,71
150	4,76	4,89	5,02	5,15	5,28	3,81	3,91	4,20	4,12	4,23
160	5,42	5,55	5,69	5,83	5,97	4,33	4,44	4,55	4,67	4,78
170	6,12	6,26	6,44	6,56	6,74	4,93	5,01	5,13	5,24	5,36
180	6,86	7,01	7,16	7,32	7,48	5,49	5,61	5,73	5,86	5,98
190	7,64	7,80	7,96	8,13	8,30	6,11	6,24	6,37	6,50	6,64
200	8,47	8,64	8,81	8,98	9,16	6,77	6,91	7,05	7,18	7,32

Annex B

(normative)

Special requirements for multilevel work platforms

Table B.1

OPTION A

Mounted on and/or below the

primary Work Platform

Requirements Single Mast Multiple Masts

Allow for the effect on calculations / Rated load
Allow for mass of multilevel work platform
Allow for additional forces on mast and mast ties
Yes Yes
Allow for additional in & out of service wind forces
Yes Yes
Allow for the effect on stability Yes Yes
Guard rails and toeboards Yes Yes
Ladder Yes Yes
Trap door Yes Yes
Fixings and stability of subsidiary work platform in relation to the primary work platform
YES, by adequate fixings to primary work platform
Supported on primary work platform or on platform extensions or both
Yes, any combination
Platform levelling according to 5.3.1.1 according to 5.3.1.1 with assurance that clearance remains between subsidiary work platform and mast for full levelling range
Controls Visibility must remain at control point
Protection from falling objects NA
Emergency lowering Standard arrangements
Buffers according to 5.3.4.10 and Instruction handbook
Upper travel limit switch Standard arrangements
Lower travel limit switch Special adjustment when subsidiary work platform is below primary work platform
Separation distance between work platforms
Fixed separation < = 3 m
Safety devices against falling (see 5.5)
Allow for any extra load
Instruction handbook Full information shall be given on how to erect and dismantle and the use of the multilevel platform

NA = Not applicable

Table B.2

OPTION B

Two or more Work Platforms

separately driven on common mast(s)

Requirements Single Mast Multiple Masts

Allow for the effect on calculations

/ Rated load
Independent calculation of each work platform
Allow for additional forces on mast
and mast ties
Yes Yes
Allow for additional in & out of
service wind forces
Yes Yes
Allow for the effect on stability Yes Yes
Guard rails and toeboards Yes Yes
Ladder No See 5.3.4.7
Trap door NA NA
Fixings and stability of subsidiary
work platform in relation to the
primary work platform
NA NA
Supported on primary work
platform or on platform extensions
NA NA
Platform levelling Separate arrangements for each platform
Controls Separate controls for each platform
Protection from falling objects Lower work platform(s) must be protected from upper work platform – See 5.3.4.4 and Instruction Manual
Emergency lowering Standard arrangements
Buffers Standard buffers according to 5.4.4
Upper travel limit switch Separate switches for each platform
Lower travel limit switch Separate switches for each platform
Separation distance between work
platforms
See 5.3.4.6
Safety devices against falling
(see 5.5)
Separate arrangements each work platform
Instruction handbook Full information shall be given on how to create and dismantle and the use of the multilevel platform

NA = Not applicable

Annex C
(normative)
Requirements for electrical and electronic aspects of overload detecting devices

C.1 Reliability

C.1.1 Electronic components shall be selected on the basis of the most unfavourable load, temperature and
tolerance parameters.

C.1.2 The power consumption of electronic components shall not exceed 66 % of the power stated by the
manufacturer at an ambient temperature outside the housing of + 60 °C.

C.1.3 Detecting devices shall be such that their sound operation is not affected by ambient temperatures
between – 20 °C and + 60 °C outside the housings. W ithin the range of these temperatures, deviation from
the set value shall not exceed + 3 %.
NOTE The design should take into account that under the circumstances described a higher temperature than + 60 °C can be reached inside the housing.

C.1.4 Electronic detecting devices or their components shall be such that their operation is not affected by:
a) Voltage pulses superimposed on the mains voltage:
Amplitude 1000 V
Pulse duration 50 µs (measured at 50 % of the peak value of the voltage pulse)
Rise time 0,2 to 0,5 µs
b) Voltage pulses between mains and earth:
Amplitude 500 V
Pulse duration 100 ns (measured at 50 % of the peak value of the voltage pulse)
Rise time 10 ns
Pulse repetition rate 10 Hz.
c) Voltage pulses between inputs or outputs and earth (common mode):
Amplitude 500 V
Pulse duration 100 ns (measured at 50 % of the peak value of the voltage pulse)
Pulse repetition rate 10 Hz
Rise time 10 ns.
d) Alternating magnetic fields:
Magnetic field strength 400 A/m
Frequency 50 Hz.
e) Electromagnetic fields:
Strength 4 V/m
Frequency 100 kHz to 500 MHz

C.2 Reporting defects

C.2.1 The occurrence in a detecting device of the defects given below in C.2.3 shall not cause inability to
switch off the MCWP if the limit value is exceeded.

C.2.2 The detecting device shall be designed and connected to the electric installation of the MCWP in such
a way that:
1) After the occurrence of one of the defects or actions given under C.2.3.1 a), the MCWP installation is
automatically switched off and can no longer be started before the defect or interruption is eliminated and
2) After occurrence of one of the defects given under C.2.3.1 b) and after the MCWP is switched off, the
MCWP can no longer be started before the defect is eliminated. This requirement does not apply if continued safe operation of the MCWP is automatically ensured by the detecting device.
NOTE The provisions under C.2.2 can be met by one of the following measures:
a) Design the circuit of the detecting device in such a way that the prescribed continued switched-off condition of the MCWP is achieved when a defect has developed;
b) Use a circuit to check the circuits in the detecting device for the presence of a defect. Such a circuit shall
be designed and connected in such a way that:

| The relevant test key shall be operated after each MCWP shut-down before the MCWP installation can be started and
| The MCWP installation cannot be started if there is a defect in the test circuit or in the detecting device;
c) Design multiple circuits in the detecting device and incorporate them in a test circuit. The test circuit shall
be designed and connected in such a way that the MCWP is switched off if there is a defect in the test
circuit or one of the parallel circuits of the detecting device;
d) Earth or connect to the frame of a circuit in which relays or solenoid switches are incorporated to ensure
the MCWP is switched off if earth or frame leakage occurs.

C.2.3 Defects to be anticipated

C.2.3.1 The following defects and actions shall be taken into account on the basis of C.2.1 and C.2.2:
a) Break, dislodging or detachment of a cable forming the connection between the individual units of the
installation which are mounted in cabinets;
| Interruption or drop in (one of) the supply voltage(s) at any moment;
b) Earth or frame leakage or interruption in the circuit;
| A relay contact or a contactor failing to open or close;
| An auxiliary switch (such as a limit switch, hand operated switch, etc.) failing to open or close;
| Interruption or short-circuit in a signal transmitter (such as a potentiometer, strain gauge bridge or transducer);
| Interrupted connection of or short-circuit in a semiconductor component (such as transistor, diode or
optocoupler) or a capacitator;

| Short-circuit or interruption in a resistor;
| A defect causing the output of an integrated circuit to give a positive or negative potential; if several similar circuits are mounted on a semiconductor printed circuit board, allowance shall be made for the same defect occurring simultaneously in all circuits.
NOTE Requirements for microprocessor applications are under consideration.

C.2.3.2 The provisions of C.2.3.1 do not apply to the following defects:
| Short-circuit between the cores of a cable if the cable satisfies the requirements provided in the relevant
national standard(s) and if the rated voltage of the auxiliary circuit does not exceed that of the cable;
| A contact not opening if the relay satisfies the requirements in EN 60947-5-1 and proper protection against influences from the ambience is installed;
| A contactor contact not opening if the contact load does not exceed 25 % of its rated power and proper
protection against influences from the ambience is installed;
| A control switch not opening which is forced open mechanically if the values specified by the manufacturer for electrical protection, rated power, method of installation, rate and angle of operation, etc,
are taken into account for installation of the contact;
| Bridging of an auxiliary switch by (an) insulation defect(s) (but do apply if this results from earth leakage
or moisture, against which a waterproof housing is often a reasonable solution);
| Interruption of or short-circuit between tracks of printed circuits if the printed circuits satisfy the applicable
requirements specified in EN 60065.

| Short-circuit in an optocoupler if the creepage paths and air gaps between the connecting wires may be
regarded as adequate and a test voltage of 2,8 kV can be sustained between the input and output circuits;
| Interruption or short-circuit in a resistor if the resistor has an insulating paint coating, a reduction of the
rate power up to approximately 66 % has been applied and short-circuit of the resistor is otherwise also
prevented (by, for example, its arrangement).

C.2.3.3 If more defects can occur in the detecting device due to a defect in a component, the provisions of
C.2.1 and C.2.2 are then also applicable.

Annex ZA

(informative)

#Relationship between this European Standard and the Essential Requirements of EU Directive 98/37/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission
and the European Free Trade Association to provide a means of conforming to Essential Requirements of the
New Approach Directive Machinery 98/37/EC, amended by 98/79/EC.
Once this standard is cited in the Official Journal of the European Communities under that Directive and has
been implemented as a national standard in at least one Member State, compliance with the normative
clauses of this standard confers, within the limits of the scope of this standard, a presumption of conformity
with the relevant Essential Requirements, except ESR 1.5.8 and 1.7.4 f), of that Directive and associated
EFTA regulations.

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within
the scope of this standard.$

Annex ZB

(informative)

#Relationship between this European Standard and the Essential Requirements of EU Directive 2006/42/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission
and the European Free Trade Association to provide a means of conforming to Essential Requirements of the
New Approach Directive Machinery 2006/42/EC.
Once this standard is cited in the Official Journal of the European Communities under that Directive and has
been implemented as a national standard in at least one Member State, compliance with the normative
clauses of this standard confers, within the limits of the scope of this standard, a presumption of conformity
with the relevant Essential Requirements, except ESR 1.5.8 and 1.7.4.2 u) of that Directive and associated
EFTA regulations.

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within
the scope of this standard.$

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BRITISH STANDARD BS EN 1570:1998

Safety requirements for lifting tables

ICS 53.020.99

+A2:2009

National foreword

This British Standard is the UK implementation of EN 1570:1998+A2:2009. It supersedes BS EN 1570:1999+A1:2004, which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags !". Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by !".

The UK participation in its preparation was entrusted to Technical Committee MHE/12, Lifting platforms, to subcommittee MHE/121-2, Lifting tables.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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BS EN 1570:1998+A2:2009

This British Standard, having been prepared under the direction of the Engineering Sector Committee, was published under the authority of the Standards Policy and Strategy Committee on 15 February 1999

Amendments/corrigenda issued since publication

Amd. No.	Date	Comments
15360	11 October 2004	Implementation of CEN amendment A1:2004
	31 October 2009	Implementation of CEN amendment A2:2009, and alignment of BSI and CEN publication dates

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EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1570:1998+A2

July 2009
ICS 53.020.99 Supersedes EN 1570:1998
English Version

Safety requirements for lifting tables

Prescriptions de sécurité des tables élévatrices Sicherheitsanforderungen an Hubtische

This European Standard was approved by CEN on 7 May 1998 and includes Amendment 1 approved by CEN on 7 June 2004 and
Amendment 2 approved by CEN on 19 June 2009.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
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EN 1570:1998+A2:2009 (E)

Foreword

This document (EN 1570:1998+A1:2009) has been prepared by Technical Committee CEN/TC 98 "Lifting platforms", the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by January 2010, and conflicting national standards shall be withdrawn at the latest by January 2010.

This document includes Amendment 1, approved by CEN on 2004-06-07 and Amendment 2, approved by CEN on 2009-06-19.

This document supersedes EN 1570:1998.

The start and finish of text introduced or altered by amendment is indicated in the text by tags ! " and # $.

This European Standard has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s).

#For relationship with EU Directive(s), see informative Annexes ZA and ZB, which are integral parts of this document.$

Normative annexes C and D give Test procedure.

#deleted text$

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Cyprus, Czech

Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia,
Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain,
Sweden, Switzerland and United Kingdom.

Introduction

#This European Standard is a type C standard as stated in EN ISO 12100-1:2003.$
This standard has been prepared to be a harmonised standard to provide one means of conforming with the
Essential Safety Requirements of the Machinery Directive and associated EFTA Regulations.
The extent to which hazards are covered is indicated in the scope of this standard. In addition, lifting tables
should comply as appropriate with #EN ISO 12100$ for hazards which are not covered by this standard.
Where, for clarity, an example of a safety measure is given in the text this shall not be considered as the only
possible solution. Any other solution leading to the same risk reduction is permissible if an equivalent level of
safety is achieved.
While producing this standard it was assumed that where there is a special requirement for a low noise level,
e.g. hospital applications, theatre applications etc. this will be specified by the customer and appropriate
measures taken by the manufacturer.
While producing this standard, it was assumed that only trained persons operate the lifting tables and that the
working area is adequately lit.
While producing this standard it was assumed that if the positioning of the lifting table creates a danger of
falling more than 3,0 m, then the necessary external precautions to reduce this to less than 3,0 m, will be
taken by the user.

1 Scope

1.1 !This document specifies the safety requirements for lifting tables for raising and/or lowering goods
and/or persons associated with the movement of goods carried by the lifting table (i.e. not for passenger use),
for a vertical travel of up to 3,0 m."

1.2 This European Standard deals with all significant hazards pertinent to lifting tables when they are used as
intended and under the conditions foreseen by the manufacturer (see clause 4). This European Standard
specifies the appropriate technical measures to eliminate or reduce risks arising from the significant hazards.

1.3 Both power operated and manually operated lifting tables are included whether stationary or mobile.

1.4 !This document does **not** apply to the following equipment:

| permanently installed lifting tables, serving specific levels of a building and fitted with a car;

| permanently installed lifting tables, serving specific levels of a building, not fitted with a car but with a
vertical travel of more than 2,0 m;
| power operated lifting platforms for persons with impaired mobility;
| lifting tables for airport ground equipment;
| lifting tables for marine use;

| mobile elevating work platforms;
| vehicle lifts for maintenance;
| mobile lifting tables used for fire fighting;
| mobile lifting tables used as fork lift trucks, pallet trucks and order pickers;
| mobile lifting tables with a travelling speed of more than 1,6 m/s;
| rail dependent storage and retrieval equipment;
| theatre stage lifts."

1.5 This standard does not consider the Power Supply to the lifting table by Internal Combustion Engine.
This standard does not establish the additional requirements for:
| Operation in severe conditions (e.g. extreme climates, freezer applications, strong magnetic fields);
| Operation subject to special rules (e.g. potentially explosive atmospheres, mines);
| Handling of loads, the nature of which could lead to dangerous situations (e.g. molten metal, acids, radiating materials, especially brittle loads);
| Hazards occurring during construction, transportation and disposal;
| Equipment installed on the load platform or replacing it;
| Integration into systems or other machines, control from more than two control stations etc.
| Cable-less controls;
| Lifting tables where the hydraulic pressure is derived directly from gas pressure.

2 Normative references

#The following referenced documents are indispensable for the application of this document. For dated
references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.$
#deleted text$
EN 294, *Safety of machinery — Safety distances to prevent danger zones being reached by upper limbs*
EN 349, *Safety of machinery — Minimum gaps to avoid crushing of parts of the human body*
EN 414, *Safety of machinery — Rules for the drafting and preparation of safety standards*
EN 418, *Safety of machinery — Emergency stop equipment, functional aspects - Principles for design*
EN 563, *Safety of machinery — Temperatures of touchable surfaces — Ergonomics data to establish*
temperature limit values for hot surfaces
EN 811, *Safety of machinery — Safety distances to prevent danger zones being reached by the lower limbs*

#EN 954-1:1996$, *Safety of machinery — Safety related parts of control systems — Part 1: General*

principles for design
EN 982, *Safety of machinery — Safety requirements for fluid power systems and their components —*
Hydraulics
EN 983, *Safety of machinery — Safety requirements for fluid power systems and their components —*
Pneumatics
!EN 1050, *Safety of machinery — Principles for risk assessment*"
EN 1088, *Safety of machinery — Interlocking devices associated with guards — Principles for design and*
selection
prEN 1760-1, *Safety of machinery — Pressure sensitive devices — Part 1: General principles for the design*
and testing of pressure sensitive mats and pressure sensitive floors
!*deleted text*"
EN 60204-1:1992, *Safety of machinery — Electrical equipment of machines — Part 1: General requirements*
(IEC 204-1:1992)
EN 60529, *Degrees of protection provided by enclosures (IP Code) #(IEC 60529:1989)*$
#EN ISO 12100-1:2003, *Safety of machinery — Basic concepts, general principles for design — Part 1:*
Basic terminology, methodology (ISO 12100-1:2003)
EN ISO 12100-2:2003, *Safety of machinery — Basic concepts, general principles for design — Part 2:*
Technical principles (ISO 12100-2:2003)$
ISO 606, *Short-pitch transmission precision roller chains and chain wheels*
ISO 2408, *Steel wire ropes for general purposes — Characteristics*
ISO 4301-1, *Cranes and lifting appliances — Classification — Part 1: General*
ISO 4308-1, *Cranes and lifting appliances — Selection of wire ropes — Part 1: General*
ISO 4308-2, *Cranes and lifting appliances — Selection of wire ropes — Part 2: Mobile cranes — Coefficient of*
utilisation

3 Definitions

For the purposes of this standard the following definitions apply:

3.1

lifting table

load lifting device with a load supporting platform guided throughout its travel (e.g. guided by its own mechanism)

3.2

fixed lifting table

a lifting table where the place of installation is not intended to be changed

3.3

moveable lifting table

a lifting table installed so that the place of installation may be readily changed

3.4

mobile lifting table

a load lifting device which is mobile by one or more integrated devices (e.g. wheels, air cushions etc)

3.5

guided mobile lifting table

a lifting table which runs on wheels on a pre-set route, (e.g. on rails, in tracks etc)

3.6

self-propelled lifting table

a lifting table, other than vehicle mounted, which is capable of horizontal movement under its own power

3.7

automatic programme controlled lifting table

a lifting table where movement takes place that is not initiated by the normal manual controls (e.g. self
levelling etc)

3.8

load platform

the part of the lifting table designed to accommodate the working load and/or persons. Fork arms are considered as a load platform for goods only

3.9

vertical travel

the vertical distance between the highest and the lowest working position for which the lifting table is designed.

3.10

nominal load

the load that the manufacturer has guaranteed that the machine will lift when used in accordance with the
instruction handbook

3.11

guard

part of machine specifically used to provide protection by means of a physical barrier

!3.12

safe by position

condition when a table or part of table is sufficiently shielded from access to avoid any hazard to persons or
goods"

3.13

emergency stop control

that component of the emergency stop equipment which generates the emergency stop signal when the
associated manual control (actuator) is operated

3.14

operator

the person operating the lifting table

3.15

maximum working pressure

the maximum pressure in the hydraulic system under normal working conditions with rated load (normally preset
by the pressure relief valve)

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4 List of hazards

!The list of hazards according to the following table is based on EN 1050.
The table has been formulated to show the hazards, hazardous situations and hazardous events which have
been identified by risk assessment to be relevant for this type of machinery and which require action to
eliminate or reduce risk.
Hazards are shown as "not applicable" where they are considered not to exist on lifting tables and "not
significant" where they are unlikely to cause risk to persons.

Table 1

Hazard	**Reference**
No	**Hazards, hazardous situations and hazardous events**	**Clause No in this standard**
1	**Mechanical hazards** due to:	
	Machine parts or work pieces, e.g.:	
a)	shape;	**5.2.1, 5.2.8**
b)	relative location	**5.2.8**
c)	mass and stability (potential energy of elements whichmay move under the effect of gravity);	**5.1.1.7**
d)	mass and velocity (kinetic energy of elements in controlled and uncontrolled motion;	**5.1.1.6**
e)	inadequacy of mechanical strength.	**5.1**
	accumulation of energy inside the machinery, e.g.:	
f)	elastic elements (springs);	**5.8.10, 5.9.6**
g)	liquids and gases under pressure;	**5.8, 5.9**
h)	the effect of vacuum	Not applicable
1.1	Crushing hazard	**5.2.1/2/3/4/6**
1.2	Shearing hazard	**5.2.1/2/3/4/6**
1.3	Cutting or severing hazard	**5.2.8**
1.4	Entanglement hazard	**5.2.9**
1.5	Drawing-in or trapping hazard	**5.2.10**
1.6	Impact hazard	**5.2.11**
1.7	Stabbing or puncture hazard	Not applicable
1.8	Friction or abrasion hazard	Not significant
1.9	High pressure fluid injection or ejection hazard	**5.8.3**

Table 1 *(continued)*

Hazard Reference No	Hazards, hazardous situations and hazardous events	Clause No in this standard
2 Electrical hazards due to:		
2.1	Contact of persons with live parts (direct contact)	**5.10.1**
2.2	Contact of persons with parts which have become live under faulty conditions (indirect contact)	**5.10.1/2**
2.3	Approach to live parts under high voltage	**5.10.1/2**
2.4	Electrostatic phenomena	Not applicable
2.5	Thermal radiation or other phenomena such as the projection of molten particles and chemical effects from short circuits, overloads, etc.	Not applicable
3 Thermal hazards, resulting in:		
3.1	Burns, scalds and other injuries by a possible contact of persons with objects or materials with an extreme high or low temperature, by flames or explosions and also by the radiation of heat sources	**5.2.16**
3.2	Damage to health by hot or cold working environment	Not applicable
4 Hazards generated by noise, resulting in #Annex B$		
4.1	Hearing loss (deafness), other physiological disorders (e.g. loss of balance, loss of awareness)	Not applicable
4.2	Interference with speech communication, acoustic signals, etc.	Not applicable
5 Hazards generated by vibration		
5.1	Use of hand-held machines resulting in a variety of neurological and vascular disorders	Not applicable
5.2	Whole body vibration, particularly when combined with poor postures	Not applicable
6 Hazards generated by radiation		
6.1	Low frequency, radio frequency radiation, micro waves	Not applicable
6.2	Infrared, visible and ultraviolet light	Not applicable
6.3	X and gamma rays	Not applicable
6.4	Alpha, beta rays, electron or ion beams, neutrons	Not applicable
6.5	Lasers	Not applicable
7 Hazards generated by materials and substances (and their constituent element) processed or used by the machinery		**5.8.2/3, 7.2.3**
7.1	Hazards from contact with or inhalation of harmful fluids, gases, mists, fumes, and dusts	**5.8.2/3, 7.2.3**
7.2	Fire or explosion hazard	Not significant
7.3	Biological or microbiological (viral or bacterial) hazards	Not applicable
8 Hazards generated by neglecting ergonomic principles in machinery design as, e.g. hazards from:		

5.6.4, 5.6.11,

5.8.11

8.1 Unhealthy postures or excessive effort **5.6.4, 5.6.11,**

5.8.11

8.2 Inadequate consideration of hand-arm or foot-leg anatomy **5.2.1/2**

8.3 Neglected use of personal protection of equipment Not applicable

8.4 Inadequate local lighting Introduction

Table 1 *(continued)*

Hazard

Reference

No

Hazards, hazardous situations and hazardous events Clause No in

this standard

8.5 Mental overload and underload, stress Not applicable

8.6 Human error, human behaviour **5.5.2, 5.5.4,**

5.5.6, 5.7.7

8.7 Inadequate design, location or identification of manual controls **5.5.1,**

5.5.3/4/5/6/7

8.8 Inadequate design or location of visual display units Not applicable

9 Combination of hazards Not specifically dealt with

10 Unexpected start-up, unexpected overrun/overspeed (or any similar malfunction) from;

10.1 Failure/disorder of the control system **5.10.1**

10.2 Restoration of energy supply after an interruption **5.10.1**

10.3 External influences on electrical equipment **5.10.1**

10.4 Other external influences (gravity, wind, etc.) **5.5.3/4/5**

10.5 Errors in the software Not dealt with

10.6 Errors made by the operator (due to mismatch of machinery with human characteristics and abilities, see 8.6) **5.5.3/4/5/6**

11 Impossibility of stopping the machine in the best possible conditions 5.5.7

12 Variations in the rotational speed of tools Not applicable

13 Failure of the power supply 5.10.1

14 Failure of the control circuit 5.10.1

15 Errors of fitting 7.3

16 Break up during operation

5.1.1, 5.7.5,

5.8.7, 5.9.7, 7.1,

7.2

17 Falling or ejected objects or fluids

5.8.1/2/3/4,

5.9.1/2/3/4,

5.2.13/14, 7.1

18 Loss of stability / overturning of machinery 5.1.2

19 Slip, trip and fall of persons (related to machinery) 5.2.13/14, 5.4.1,

5.2.17

Additional Hazards, hazardous situations and hazardous events due to mobility

20 Relating to the travelling function

20.1 Movement when starting the engine **5.6.3**

20.2 Movement without a driver at the driving position **5.6.2**

20.3 Movement without all parts in safe position **5.2.19, 5.3.2**

20.4 Excessive speed of pedestrian controlled machinery **5.3.2**

20.5 Excessive oscillations when moving **5.3.3**

20.6 Insufficient ability of machinery to be slowed down, stopped and immobilised

5.6.2, 5.6.5,

5.6.8

Table 1 *(continued)*

Hazard

Reference

No

Hazards, hazardous situations and hazardous events Clause No in

this standard

21 Linked to the work position (including driving station) on the machine

21.1 Fall of persons during access to (or at/from) the work position Not dealt with

21.2 Exhaust gases/lack of oxygen at the work position Not dealt with

21.3 Fire (flammability of the cab, lack of extinguishing means) Not dealt with

21.4

Mechanical hazards at the work position:

i) Contact with the wheels; **5.6.5**

j) Rollover; **5.1.2.1**

k) Fall of objects, penetration by objects; **5.2.13/14**

l) Break-up of parts rotating at high speed; Not dealt with

m) Contact of persons with machine parts or tools (pedestrian controlled machines). **5.2.11**

21.5 Insufficient visibility from the work positions **5.5.1**

21.6 Inadequate lighting Introduction

21.7 Inadequate seating Not applicable

21.8 Noise at work position **Annex B**

Not dealt with

21.9 Vibration at the work position Not applicable

21.10 Insufficient means for evacuation/emergency exit Not applicable

22 Due to control system

22.1 Inadequate location of manual controls **5.5.1**

22.2 Inadequate design of manual controls and their mode of operation **5.5.3/4/5, 5.6.2**

23 From handling the machine (lack of stability) 7.1

24 Due to the power source and to the transmission of power

24.1 Hazards from the engine and the batteries Not applicable

24.2 Hazards from transmission of power between machines Not applicable

24.3 Hazards from coupling and towing **5.6.7**

25 From/to third persons

25.1 Unauthorised start-up/use **5.5.3**

25.2 Drift of a part away from its stopping position **5.5.2, 5.6.1/2/3**

25.3 Lack or inadequacy of visual or acoustic warning means **5.2.11**

26 Insufficient instructions for the driver/operator 7.1,

Introduction

Additional hazards, hazardous situations and hazardous events due to lifting

27 Mechanical hazards and hazardous events

27.1 from load falls, collisions, machine tipping caused by:

27.1.1 lack of stability **5.1.2.1**

Table 1 *(concluded)*

Hazard	**Reference**
No	
Hazards, hazardous situations and hazardous events	**Clause No in this standard**
27.1.2 uncontrolled loading – overloading – overturning – moments exceeded	**Annex A**
	5.1.2.1/2, 5.8.4,
	5.9.4, 5.1.2.1/2,
	5.7.11/12,

6.9.6.12

27.1.3 uncontrolled amplitude of movements **5.5.2**

27.1.4 unexpected/unintended movement of loads **5.4.3**

27.1.5 inadequate holding devices/accessories **5.8.9, 5.9.8, 7.1**

27.1.6 collision of more than one machine Not dealt with

27.2 from access of persons to load support **6.10, 6.11**

27.3 from derailment **5.6.8**

27.4 from in sufficient mechanical strength of parts **5.1, 8.1.5**

27.5 from inadequate design of pulleys, drums **5.7.1/2/3**

27.6 from inadequate selection of chains, ropes, lifting and accessories and their inadequate integration into the machine **5.7.4**

27.7 from lowering of the load under the control of friction brake **5.7.15**

27.8 from abnormal conditions of assembly/testing/use/maintenance **7.1, 8.1.7.1**

27.9 from the effect of load on persons (impact by loading or counterweight) **5.2.14, 7.1**

28 Electrical hazards

28.1 from lightning Not applicable

29 Hazards generated by neglecting ergonomic principles

29.1 insufficient visibility from the driving position **5.2.15, 5.5.1**

Additional hazards, hazardous situations and hazardous events due to underground work

30 Mechanical hazards and hazardous events due to:

30.1 lack of stability of powered roof supports Not applicable

30.2 failing accelerator or brake control of machinery running on rails Not applicable

30.3 failing or lack of deadman's control of machinery running on rails Not applicable

31 Restricted movement of persons Not applicable

32 Fire and explosion Not applicable

33 Emission of dust, gases etc. Not applicable

Additional hazards, hazardous situations and hazardous events due to the lifting or moving of persons

34 Mechanical hazards and hazardous events due to:

34.1 inadequate mechanical strength – inadequate working coefficients **5.1**

34.2 failing of loading control **5.1.2**

34.3 failing of controls in person carrier (function, priority) **5.5.2**

34.4 overspeed of person carrier **5.3, 5.7.5, 5.8.7,**

5.9.7

35 Falling of person from person carrier 5.2.12/13/14

36 Falling or overturning of person carrier 5.1.2

37 Human error, human behaviour 6.0

"

5 Safety requirements

5.1 Calculations

5.1.1 Stress

5.1.1.1 The lifting table shall be designed in accordance with usual calculation codes and good engineering
practice and all failure modes of the material shall be considered including fatigue failure.

5.1.1.2 The stresses in any part of the lifting table, using the permissible stress method, under normal
working conditions, shall not exceed the following:
a) 0,66 times the yield stress of the material used;
b) 0,50 times the ultimate tensile stress of the material used.

5.1.1.3 The stresses shall be calculated for the condition of the lifting table carrying its rated load and being
used in accordance with the manufacturer's instructions.
The loads shall include all actual static and dynamic forces both vertical and horizontal, all wind forces, and all
forces applied to the platform during loading and unloading.

5.1.1.4 The minimum dynamic forces to be used for the calculations of 5.1.1.3 shall result from:
a) the total vertical load (this includes the rated load and the selfweight of the moving parts of the structure)
increased by 40 % and;
b) 10 % of the rated load taken as acting horizontally at platform level, in the direction causing the maximum
stress in the part being considered.
If side barriers prevent movement of the load in a particular direction this direction need not be considered.

5.1.1.5 If persons are to be carried on the platform, their load shall be taken as 80 kg, concentrated in an
area of 0,2 m by 0,2 m for each person, spaced apart at 0,5 m centre to centre and placed in the most
unfavourable position on the platform for stress calculations.

5.1.1.6 It shall be possible for the forces produced when the safety device is operated, to be accepted
without permanent deformation of the normal load bearing parts, when used in accordance with the manufacturer's instructions.

5.1.1.7 Every lifting table shall also be designed to at least:
1) in one case lift half the rated load distributed over half the length of the platform;
2) and in another case lift one third of the rated load distributed over half the width of the platform.
In neither case shall hazardous tilting or deflection take place when used as intended by the manufacturer.

5.1.2 Stability

5.1.2.1 Lifting tables shall be stable (i.e. will not overturn) in all conditions of the platform or table, whether
stationary or moving.
The calculated factor of safety shall not be less than 1,3. This shall be calculated by dividing the sum of all the

stabilising moments by the sum of all the worst overturning moments. The overturning moments are to include
all dynamic forces and all externally imposed forces including those caused by transfer on and off the platform
and those caused by persons.
For this calculation the rated load shall be evenly distributed over an area of half the length times half the
width of the platform, in the worst overturning position.
The "tilting edge" is to be decided by the manufacturer.

5.1.2.2 Where persons are to be carried on the platform, the worst overturning movement of these persons
shall be taken into account in these calculations. Manual forces applied by persons on the platform shall be
multiplied by a factor of 1,1 and taken to be acting in the direction creating the greater overturning moment.

5.1.2.3 If the lifting table is capable of tilting, the worst overturning position shall include the maximum tilt.

5.1.2.4 In the case of mobile lifting tables, it shall be assumed that they are raising and lowering on a slope
of 2,5 % (1 in 40) in the worst direction for stability.

5.1.2.5 For these calculations it shall be assumed that outriggers or stabilisers are correctly set.

5.2 Safeguarding

5.2.1 Generally crushing and shearing shall be avoided by the following minimum gaps between moving
parts and between moving and fixed parts:

- for fingers 25 mm;
- for toes 50 mm;
- for hands 100 mm;
- for arms and closed hands 120 mm;
- for feet 120 mm;
- for the body 500 mm.

5.2.2 As an alternative to these minimum gaps other safety measures shall be taken to avoid the operator or
any other persons being endangered e.g.

- Screen;
- Barriers;
- Deflectors;
- Non-mechanically actuated trip device complying with prEN 50100;
- Mechanically actuated trip device complying with category 1 of #EN 954-1:1996$;

- Multiple controls requiring simultaneous operation.

Some of these examples will not be sufficient by themselves in particular cases.
Dimensions in millimetres

Figure 1 — Gaps between lifting table arms and base

5.2.3 !In scissor type lifts the minimum safety gaps between the scissor legs and the outer scissor leg and
the base frame shall be as shown in Figure 1."

5.2.4 When lowering a minimum of free space for the feet shall be provided in accordance with figure 2 to
prevent crushing and shearing of feet.
Dimensions in millimetres

Figure 2 — Minimum foot clearances when lowering

5.2.5 Where the machine is totally enclosed by the manufacturer with an imperforate rigid guard or is "safe
by position" the minimum gaps given in 5.2.1 are not necessary. If the machine is only partly enclosed by an
imperforate rigid guard, then these gaps or an acceptable alternative (in accordance with clause 5.2.2), shall
be provided in the parts of the machine not enclosed.
If a perforate rigid guard is used then this shall comply with the requirements of standards EN 294 and
EN 811.

5.2.6 If a mechanically actuated trip device is fitted to the outer edges of the platform then it is necessary to
maintain only the minimum gaps for fingers inside the area safeguarded by the device.
The outer surface of the device shall be not more than 8 mm from the outer edge of the platform as shown in
figure 3.

Dimensions in millimetres

Figure 3 — Arrangement of mechanically actuated trip device

5.2.7 Safety devices shall operate so that the moving part causing the hazard comes to a stop before injury
is caused. They shall not create another hazard.
Where a mechanically actuated trip device (e.g. hanging or pivoted trip bar) is fitted to the underside of the
platform, the trip device when actuated shall stop all movement of the platform downwards and hold it stopped
until the Down control has been released, the obstruction removed, the device reset (either manually or
automatically) and the down control re-operated.
It shall always be possible to raise the platform in order to clear the obstruction.

5.2.8 All moving parts and parts which pass each other or fixed structures, and which persons may contact,
shall have no sharp edges, no sharp angles and no rough surfaces.

5.2.9 All moving parts that could entangle a person or their clothing shall be avoided by design or where this
is not possible they shall be guarded.

5.2.10 All nip points (belts, chains, ropes passing over pulleys flexible couplings, elements of telescopic
guides, etc) shall be safeguarded to prevent drawing-in or injury to any persons. Care shall be taken that the
guard itself does not form a hazard.

5.2.11 !Self-propelled lifting tables that are manually controlled shall be fitted with an audible warning device controlled from the operating position.

If the automatically controlled lifting table is intended to be used in an area from which persons are not
excluded, persons shall be automatically protected from impact of the lifting table (e.g. by pressure sensitive
buffers or photo-electric devices) and an acoustic and/or visual warning device (e.g. flashing lamp) shall
operate whenever movement takes place."

5.2.12 Lifting tables which have a fixed control point on the platform, shall have at least one standing place
with an area of 0,5 m by 0,6 m, with a secure handhold for the operator. If outward opening gates are fitted
they shall be automatically interlocked (e.g. electrically, pneumatically) with the control system of the vertical
travel of the platform (interlocks shall be in accordance with EN 1088).

5.2.13 All lifting tables that have a vertical travel of more than 2,0 m shall be fitted with means to prevent
persons or goods falling from the platform.

5.2.14 For persons these means shall, as a minimum, consist of guard-rails at least 1,1 m high, toeguards at
0,15 m high and intermediate guard-rails not further than 0,5 m from either the guard-rail or toeguards.
If gates or opening parts of the barrier are fitted, they shall be interlocked with the control system so that the
platform can be moved only when the barrier is closed. Furthermore outward opening parts shall be
interlocked in such a way that these parts can only be opened when the platform is in a clearly defined access
position.

Goods shall be prevented from falling from the platform as described in the instructions for use (see 7.1).

5.2.15 In the case of operator-carrying lifting tables where controls are mounted on the platform, safety
precautions shall be taken to protect persons in the hazard area under the platform. e.g. Pressure mats
(complying with EN 1760-1) or the fitting of mechanically actuated trip devices together with warning notices
(see 5.2.18).

5.2.16 If any parts of the driving system (e.g. hydraulic tanks, motors etc.) are designed to operate at a
temperature of above 55 °C, these parts shall be pr otected or positioned to avoid contact of persons.

5.2.17 A manually operated blocking device shall be fitted to all lifting tables to allow maintenance work to be
carried out below the platform in safety. This device shall be capable of supporting the platform with its rated
load, and of being operated from a safe position.
This requirement does not apply to lifting tables which are designed to enable all maintenance work to be
carried out when the platform is fully lowered on to mechanical depth stops.

5.2.18 Lifting tables which operate in areas to which the public (especially small children) could reasonably be

foreseen to have access, shall be enclosed by a rigid guard to prevent the hazard due to the descending
platform. Alternatively a semi-rigid guard (e.g. mesh or material) can be fitted in conjunction with a mechanically actuated trip device.

5.2.19 All lifting tables with power operated lifting and lowering movements and fitted with retractable outriggers, shall have the raising/lowering system interlocked with the correct setting of the outriggers.

5.2.20 Devices shall be fitted to all lifting tables to stop the descent of the platform if the descent speed of the
platform exceeds the maximum design speed. The platform shall be stopped before the descent speed
exceeds 0,25 m/s.
This does not apply to structural failure.
If pipe rupture valves are used to stop the platform on multi-cylinder driven machines, it shall be impossible for
any hydraulic cylinder to be overloaded by more than 100 %.

5.2.21 #When it is foreseen (e.g. maintenance) that fixed guards will be removed then the fastenings shall
remain attached to the guards or to the lifting table.$

5.3 Speeds

5.3.1 The lifting and lowering speeds of the platform shall not exceed 0,15 m/s, except where the platform is
automatically programme controlled and "safe by position".

5.3.2 The horizontal travelling speed of pedestrian controlled lifting tables without remote control shall not
exceed 1,1 m/s, when travelling with the platform fully lowered.
The horizontal travelling speed of pedestrian controlled lifting tables with remote control, shall not exceed
1,6 m/s, when travelling with the platform fully lowered, but shall also be capable of having their speed
reduced to 1,1 m/s, by the operator.
The horizontal travelling speed of "ride-on" self-propelled lifting tables shall not exceed 1,6 m/s, when travelling with the platform fully lowered.
When the platform is not fully lowered the travelling speed shall be automatically limited to not more than
0,6 m/s, except where the platform is "safe by position".

5.3.3 Where a platform is designed to be tilted or rotated, the peripheral speed of the platform shall be
limited to not more than 0,15 m/s, except where the platform is "safe by position".

5.4 Platform

5.4.1 Platforms which are entered by persons shall be fitted with an anti-slip surface (e.g. Durbar plate, grit
surface, anti-slip mats).

5.4.2 Where a platform is designed to be tilted, it shall have an automatic and fixed method of preventing the
intended load, or any parts thereof, falling unintentionally from the platform when tilted.

5.4.3 Platforms that are designed to carry wheeled loads shall be shaped or have a device that will prevent
the intended load from unintentionally rolling off. This device shall retract only when the platform is in a safe
position for transfer of the load. This also applies to rolling loads (reels, cylinders etc).

5.4.4 Emergency lowering devices, where fitted, shall be of the hold-to-run type. These devices shall be
fitted in a safely accessible position and shall not be capable of unauthorised operation.

5.4.5 Where the platform surface, or part of it (e.g. a turntable), can rotate, and it can be walked on at
bottom level, an arrangement shall be present which prevents unintentional rotation when lowered.

5.5 Operator control position

5.5.1 The operator's position shall give the operator a clear view of the hazardous parts of the platform and
its load at all times throughout its vertical movement (see 5.2.15).
If the operator's position is not determined by the manufacturer, see clause 7.
In the case of self-propelled lifting tables the operator shall have a clear view of the horizontal travel of the
lifting table.
NOTE 1 In some cases more than one operator position will be required to meet this requirement.
Control devices shall be designed and arranged so that they are within easy reach of the operator.

5.5.2 All controls shall be of the hold-to-run type. This does not apply to automatically controlled movements
of the lifting table.

5.5.3 A device shall be fitted to all power operated lifting tables to prevent unauthorised use (see annex E).

5.5.4 The control devices shall be designed so that the movement of the control and its location are consistent with its effect (see annex E).

5.5.5 All controls except emergency stops shall be designed to prevent unintentional operation. (see annex E).
NOTE 1 Levers of hand or foot pumps which are only used to lift the platform are not controls in the sense of this
clause.

5.5.6 !Where alternative controls are fitted at two different positions they shall be wired so that only one
set can be in use at any one time, excluding the emergency stop.
Where one set of alternative controls are mounted on the platform, operation of the platform controls shall
always have priority, when operated, over the remotely sited controls, excluding the emergency stop."

5.5.7 For power-operated lifting tables, emergency stop controls in accordance with EN 418 category O,
shall be provided at each control position. If there is only a control position on the platform, there must be at
least one additional emergency stop control not on the platform and in a convenient accessible position. If this
control position is not determined by the manufacturer see clause 7.

5.5.8 Where the platform is capable of tilting more than 5 degrees from the horizontal, the operator position
shall not be on the platform.

5.6 Mobile lifting tables

5.6.1 All manually operated mobile lifting tables shall be fitted with a device to prevent unintentional movements of the lifting table (e.g. parking brake, truck lock).

5.6.2 Self-propelled mobile lifting tables shall have fitted an automatic brake for the horizontal movement
which is normally held on and which is released only by application of power. Operation is also instigated
automatically by releasing the travelling controls and by interruption of the power supply. This applies whether
the horizontal movement is controlled by an operator or by automatic programming. Maintaining the braking
(holding) effect shall not depend upon an exhaustible energy source.
The brake shall be dimensioned such that they can stop a loaded lifting table travelling at its maximum speed
stated by the manufacturer and on a slope two degrees greater than that stated by the manufacturer.
This brake shall also act as the parking brake on these machines.
Alternatively the braking effect can be supplied by a hydrostatic driving system if this gives an equivalent
effect. In this case a separate parking brake shall be fitted.

5.6.3 On self-propelled mobile lifting tables, switching on or starting the motor shall not produce any unintentional movements of the table.

5.6.4 Manually driven lifting tables shall be fitted with handles for pulling or pushing unless the table structure can safely be used for this purpose. These handles should be so mounted that injuries, especially to
the hands or feet, are minimised during movement.

5.6.5 !To ensure the operators safety, the wheels on the lifting table shall be positioned in accordance
with Figure 4, where:

| either *h* is less than 35 mm and *l* is a minimum of 10 mm, or
| *h* = 35 mm to 70 mm and *l* is a minimum of 2,57 *h* - 80 mm, or
| *h* = 70 mm to 120 mm and *l* is a minimum of 1,60 h - 12 mm."

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!
Dimensions in millimetres

Key

1 frame edge
2 frame of truck
3 ground (floor)
4 wheel
5 frame height above ground
6 free space for feet
h height of frame above ground
l minimum distance of free space for feet

Figure 4 — Free space for feet"

5.6.6 Where wheels cannot safely be arranged in accordance with 5.6.5, a wheel guard (deflector) as shown

(including operators and loaders) and not less than 6 for other lifting tables.
The rope terminations shall be able to resist at least 80 % of the minimum guaranteed breaking load of the
rope.
On the lifting tables intended to carry persons there shall be at least two independent supporting ropes.
A device shall be provided to give approximate equal tension in all supporting ropes. When ropes are reeved,
the number of ropes to be taken into account shall be the number of independent ropes, not the number of
falls.

5.7.2 The ratio of the drum pitch diameter or pulley pitch diameter to the diameter of the wire rope shall in no
case be less than 18:1. At least two turns of the rope shall remain on the drum at all times.
The rope shall be prevented from becoming tangled on the drum (e.g. by the provision of a single continuous
spiral groove or other equally effective means).
Means shall be provided to prevent the wire rope from leaving the ends of the drum, e.g. flanges extending to
a height of at least twice the wire rope diameter above the highest layer.

5.7.3 For pulleys the following requirements shall be fulfilled:
The grooves shall be circular with a radius not more than 7,5 % and not less than 5 % in excess of half the
nominal diameter of the wire rope. The depth shall be not less than 1,5 times the nominal diameter of the wire
rope.
Pulleys having wire ropes leading upwards shall be protected against the penetration of foreign bodies.
Effective precautions shall be taken to avoid wire ropes leaving their grooves.

5.7.4 Chains used as suspension elements shall be leaf or roller type only. They shall be dimensioned in
accordance with ISO 606.
The safety factor, calculated as the guaranteed total breaking load of all the chains divided by the maximum
static support load, shall not be less than 10 for lifting tables intended to carry persons (including operators
and loaders) and not less than 6 for other lifting tables.
Where chains are reeved, the number of chains to be taken into account shall be the number of independent
chains not the number of falls.

5.7.5 All mechanical driving systems shall be fitted with safety gear to stop the descent of the platform within
100 mm and hold the platform, in the event of a breakage of any part of the lifting mechanism. When actuated
the safety gear shall also stop the drive motor and keep it stopped. (see also clause 7).
Final limit switches and wire rope/chain rupture switches shall, if actuated, stop the lifting table and keep it
stopped. They shall fulfil the requirements of 5.11.2.
Final switches shall stop movement before contact with any fixed parts.

5.7.12 All lifting tables using a mechanical driving system with screws or rack and pinions for lifting shall be
fitted with an overload device which will only allow a motor torque to be developed of 150 % of the motor
torque that is developed when raising the rated load.

5.7.13 Control mechanisms of manually operated lifting tables shall be designed in such a way that:

a) winding handles, levers or wheels cannot turn back under load more than 15 cm measured at the greatest radius of the control (reversal security). Reversal security shall not be necessary for hand-wheels
if these take the form of completely smooth discs without any handles;

b) the direction of rotation of winding handles remain the same regardless of gearing;

!

c) removable winding handles, levers and hand wheels shall be secured against slipping and unintentional
removal from the drive shaft, e.g. fitting securing mechanism such as snap-in latches or locking springs;"

d) it shall not be possible for the drive to become disengaged during gearing changes.

5.7.14 A braking system shall be fitted on all drives. The braking system shall be automatically applied when
the drive is no longer energised.
This braking system shall ensure that the loaded platform can be stopped and held at any position under all
possible conditions of operation. Unintentional release of this device shall not be possible.

5.7.15 All drives used for lifting shall be of a positive type. (e.g. gear/chain transmission) Friction drives (e.g.
belt transmission, friction clutches), shall not be used.

5.8 Hydraulic system

5.8.1 The hydraulic system shall conform to the requirements of EN 982.

5.8.2 All hydraulic cylinders, pipes, valves, fittings etc. shall be designed to withstand a static pressure equal
to twice the maximum working pressure without permanent deformation.

5.8.3 All hydraulic hoses and their fittings shall be designed for a bursting pressure of at least three times
the maximum working pressure.

5.8.4 A pressure relief valve shall be fitted in all systems and shall be positioned and set so that not more
than 110 % of the maximum working pressure can be achieved. Where adjustable, the adjustment of this
valve shall require the use of tools.
It shall be positioned so that it will not cause the platform to descend out of control if an overload is placed on
the raised platform.

5.8.5 It shall not be possible for the hydraulic fluid to drain out of the cylinders if the platform descent is
blocked and the lowering control still actuated.

5.8.6 On all hydraulic circuits it shall be easily possible to connect a device to measure the hydraulic pressure in the circuit. This fitting shall be specified in the manufacturer's maintenance instructions.

5.8.7 All hydraulic drives shall be equipped with an automatic fail-safe device to limit unintentional lowering
of the platform to a maximum of 100 mm and to stop the platform at any height, in case of rupture in the
hydraulic supply line. This device shall be designed to carry 150 % of the rated load.
Under failure conditions the level of the platform shall be maintained to a maximum tilt of 5°.

5.8.8 The minimum fluid level in the tank shall be clearly indicated for a particular platform height e.g. this
could be either a sight glass on the tank or a dip stick, with a level marked on it for a platform height.

5.8.9 Safety devices shall be fitted to prevent descent due to hydraulic leak, where this could produce a
hazard for persons. e.g. Where the elevated platform forms part of a floor.

5.8.10 In hydraulic systems incorporating hydraulic accumulators, means shall be provided to vent the
accumulator liquid pressure automatically or to positively isolate the accumulator when the system is in the
unpressurised state.

5.8.11 When a hand pump is used to operate the lifting table, the operating force on the handle provided,
measured at the end of the handle when raising the rated load, shall not exceed 200 N when operating
according to the manufacturers instructions. This figure (200 N) may be increased to 300 N for foot pumps.
(See annex F for force measurement methods).

5.9 Pneumatic system

5.9.1 The pneumatic system shall conform to the requirements of EN 983.

5.9.2 All pneumatic cylinders, pipes, valves, fittings etc. shall be designed to withstand a static pressure
equal to twice the maximum working pressure without permanent deformation.

5.9.3 All pneumatic hoses and their fittings shall be designed for a bursting pressure of at least three times
the maximum working pressure.

5.9.4 A pressure relief valve shall be fitted in all systems and shall be positioned and set so that not more
than 110 % of the maximum working pressure can be achieved. Where adjustable, the adjustment of this
valve shall require the use of tools.
It shall be positioned so that it will not cause the platform to descend out of control if an overload is placed on
the raised platform.

5.9.5 On all pneumatic circuits it shall be easily possible to connect a device to measure the pneumatic
pressure in the circuit. This fitting shall be specified in the manufacturers maintenance instructions.

5.9.6 Protection shall be provided against the hazard caused by the platform raising or lowering without a
control action when a load is placed on or removed from the platform, thus varying the pneumatic pressure in

the cylinder.

5.9.7 All pneumatic drives shall be equipped with an automatic fail-safe brake to limit unintentional lowering
of the platform to a maximum of 100 mm. and to stop the platform at any height, in case of rupture in the
pneumatic supply line. This device shall be designed to carry 150 % of the rated load.
Under failure conditions the level of the platform shall be maintained to a maximum tilt of 5°.

5.9.8 Safety devices shall be fitted to prevent descent due to pneumatic leak, where this could produce a
hazard for persons. e.g. Where the elevated platform forms part of a floor.

5.9.9 Lifting tables which are designed to be used at a temperature below 10 °C shall be designed so that
ice formation is prevented, e.g. by the metering of spirits.

5.10 Electrical system

5.10.1 General

The electrical installation and equipment of lifting tables shall conform to the requirements of EN 60204-1.

5.10.2 Electrical installations and equipment

Protection against direct contact shall be provided by means of enclosures as detailed in EN 60529.

5.11 Safety devices

5.11.1 All safety devices shall be designed so that they cannot be rendered inoperative by simple means,
(e.g. insertion of a wedge or block) unless the devices are not readily accessible to people.

5.11.2 For drives other than hydraulic or pneumatic, end of travel limit switches shall be provided at the upper
end of the travel of the platform and shall be set to operate as closely as possible to the upper terminal stop.
End of travel limit switches shall be mechanically actuated with positive opening contacts (see EN 60947-5-1)
and shall, when operated, cause the lifting table to stop and remain stopped.

6 Marking

6.1 All labels, notices and operating instructions shall be legible and readily understandable (if necessary
aided by signs of symbols). They shall be untearable, of durable material and permanently fixed. (e.g. metal or
plastic stuck or riveted to the table). They shall be in a visible position and written in the language of the
country where the lifting table is to be installed.

6.2 The direction of movement shall be marked with pictograms or other easily recognisable signs on, or
alongside, all control buttons, levers and handwheels.

6.3 If supplied by the manufacturer, the main isolating device shall be marked "Main Switch" or similarly
described in the case of other power supplies e.g. pneumatic.

6.4 All lifting tables shall be marked with the following information on a single plate;

a) Rated load and distribution;

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b) business name and full address of the manufacturer and, where applicable, his authorised representative;$

c) Type and serial number;

d) I.P. Code;

#

e) designation of the machinery;

f) the year of construction, that is the year in which the manufacturing process is completed.$

6.5 All lifting tables shall have a warning notice permanently fixed, in letters at least 15 mm high as follows:

DO NOT ENTER UNDER THIS PLATFORM UNLESS IT IS MECHANICALLY LOCKED

together with the "personnel prohibited" pictogram.

6.6 Mobile or movable lifting tables shall be marked with their own mass (self weight).

6.7 Lifting tables operated by an external hydraulic or pneumatic supply shall be marked with the maximum
operating pressure.

6.8 All electrically operated lifting tables shall be clearly and permanently marked with the permissible supply
voltage and the nominal power in kilowatt.

6.9 The rated load of all lifting tables shall be clearly and permanently marked on the working platform of the
actual machine.

6.10 Lifting tables which are not designed to carry persons shall be clearly marked with a notice and/or a
symbol prohibiting this.

6.11 Lifting tables which are designed to carry persons associated with the movement of goods only, shall
clearly exhibit a notice prohibiting carriage of passengers.

6.12 Fully manually operated lifting tables with outriggers, shall have a warning notice stating that the outriggers shall be correctly set before lifting or lowering.

6.13 !For scissor lift tables a warning notice shall be provided stating "Danger. Do not put hands or feet
under the platform", with the appropriate pictogram."

6.14 Hydraulic fluid power systems with an accumulator shall have a warning label on the accumulator e.g.
"Caution - de-pressurise before maintenance".

7 Information for use

7.1 The manufacturer shall supply with each lifting table a set of operating instructions sufficient for safe
operation of the lifting table, in a language of the country where the lifting table is to be installed. These shall
include:

a) All the notices installed on or at the lifting table;

b) The intended use of the lifting table, together with warning against common misuses e.g. as MEWPs or

lifts and including loading conditions and distribution;
c) Commissioning and de-commissioning instructions;
d) Operation of the controls and the emergency control, including possible misuses;
e) Safety conditions for the opening of the barrier gates where applicable;
f) Loading and securing the load, including possible misuses;
g) Details of the safety devices;
h) Instructions for moving the lifting table where applicable, including the use of safety shoes etc. when
moving manually;
i) Procedure in the event of a malfunction;
k) The intended environment of use;

#
l) noise emission data according to Annex B;
m) the specifications of the spare parts to be used, when these affect the health and safety of operators.$

7.1.1 These instructions shall mention the residual hazards present during the use of the lifting table e.g.
Risks when handling heavy loads, or related to intensive load handling on mobile tables, or to excessive
forces needed to move mobile tables where floor conditions are poor.

7.1.2 A statement that a notice shall be permanently fixed in a visible position at the control(s) position(s),
stating that only authorised persons are allowed to operate the lifting table.

7.1.3 In positions where overloading is possible, the user shall supply the necessary warning notices against
the residual risk of overloading.

7.1.4 A statement that after the excess speed device (in 5.2.20) has operated, the reason for the operation
shall be investigated before continuing to operate the lifting table.

7.1.5 Full instructions shall be given as to the measures to be taken if permanent deformation occurs in a
safety gear after operation, e.g. replacement of the part, removal of burr etc.

7.1.6 Where a towbar is needed that is not supplied by the manufacturer the instructions shall state that it
shall not be possible for coupling devices between the lifting table and the towing vehicle to become unintentionally detached.

7.1.7 If a turntable is fitted these instructions shall include the method of operating and locking this turntable.

7.1.8 These instructions shall include a list of the excluded machines and environments etc. as given in 1.4
and 1.5, of this standard.

7.2 The manufacturer shall supply with each lifting table a set of instructions sufficient to inspect, maintain and
repair the lifting table including access methods and replacement periods of parts. These shall state that any
replacement parts required for the lifting table shall be obtained from the original manufacturer of the lifting
table or be of at least equivalent quality and safety.

7.2.1 The maintenance instructions shall include the specifications of the replacement hydraulic hoses used
on the lifting table.

7.2.2 The maintenance instructions shall include the type and characteristics of the hydraulic fluid recommended for the system (not solely by the manufacturer's trade name).

7.2.3 The maintenance instructions shall include a warning against the possible leakage of hydraulic fluid
and the possible consequences.

7.2.4 When a major repair has been carried out the lifting table shall be re-tested according to annex C.

7.3 The manufacturer shall supply with each lifting table a set of instructions sufficient for the safe assembly,
installation and dismantling of the lifting table.

7.3.1 The installation instructions shall state that during installation care shall be taken to avoid mounting the
lifting table in a position where the noise of the table is magnified.

7.3.2 The installation instructions shall specify the safety clearances needed between any moving parts of
the lifting table and any adjacent walls or other objects, either fixed or moving.

7.3.3 The installation instructions shall state the need to comply with the applicable Building and Safe Use
Regulations.

7.3.4 The installation instruction shall state that where the installation is such that there is a risk of falling a
vertical distance of more than 3 m further precautions may be necessary.

7.3.5 The instructions shall include the need to site the control position in accordance with 5.5.1.

7.3.6 These instructions shall state the need to comply with 5.5.7, the positioning of Emergency Stop controls.

7.3.7 The installation instructions shall state the need for the Emergency Lowering valve to be positioned to
give the operator full control and visibility over the platform lowering at all times.

7.4 Electrical and hydraulic/pneumatic circuit diagrams, sufficient for safe maintenance, shall be supplied
where applicable.

8 Verification of the safety requirements and/or measures

8.1 General

8.1.1 Tests

The tests described in this clause can be used to verify the compliance of lifting tables and their components
with this standard.

The checks and tests, to ensure that the lifting table complies with this standard, shall consist of:

a) design check (see 8.1.2);
b) manufacturing check (see 8.1.3);
c) visual verification (see 8.1.4);

d) practical tests (see 8.1.5);
e) electrical tests (see 8.1.6);
f) final inspection before despatch (see 8.1.7).
A type test shall consist of 8.1.2, 8.1.3, 8.1.4, 8.1.5 and 8.1.6.
An individual machine testing shall consist of 8.1.7.

!The result of the examinations and tests shall be recorded in a signed report (e.g. as shown in Annex D)
and the identity of the person signing the report shall be clearly shown."

8.1.2 Design check

The design check shall verify that one type of lifting table has been designed in accordance with this standard.
It shall at least be checked that:
a) the drawings give the main dimensions of the lifting table;
b) there is a description of the lifting table with the necessary information about its capabilities;
c) information is given concerning the materials and proprietary components used;
d) diagrams of the hydraulic, pneumatic and electrical circuits are available;
e) Instructions covering installation, commissioning, operating, maintenance and dismantling are available.
The documents shall give all the necessary information to enable:
a) the structural calculations to be checked;
b) the stability calculations to be checked.

8.1.3 Manufacturing check

The manufacturing check shall verify that:
a) the lifting table has been manufactured in accordance with the checked documents and drawings;
b) Test certificates are available for all the wire ropes, chains and hoses;
c) all welding has been carried out according to the drawings and specifications.

8.1.4 Visual inspection

It shall be visually checked that:
a) all the markings specified in clause 6 have been affixed to the lifting table;
b) the lifting table is in accordance with all the documentation provided by the manufacturer.

8.1.5 Practical tests

Practical tests as detailed in C1 for type testing and C2 for individual machine final verification, shall be carried
out to verify that:
a) the lifting table is stable;
b) the lifting table is structurally sound;
c) all the functions of the lifting table can be safely and correctly carried out.

8.1.6 Electrical tests

The electrical tests shall be carried out in accordance with EN 60204-1, where applicable.

8.1.7 Individual final verification before despatch

8.1.7.1 Before despatch of each lifting table, a verification shall show that the lifting table satisfies the

safety requirements of this standard. Where the lifting table is assembled on site, this verification shall be
made at the place of use before the machine is put into service, and a record made of the results, (as shown
in annex D).

8.1.7.2 If a type test for the lifting table model has been carried out and the individual lifting table has been
produced in accordance with an agreed Quality Assurance procedure, then it is only necessary to functionally
test each individual lifting table with the rated load plus 10 % throughout its full travel.

8.1.7.3 Where the lifting table has not been manufactured using an agreed Quality Assurance system, the
final verification shall consist of tests and verifications in accordance with 8.1.2, 8.1.3, 8.1.4, 8.1.5, 8.1.6.

Annex A
(informative)
Overloading

The requirements of a load control device for these machines cannot be fully met in this standard.

Table A.1 — Analysis of possible overload situations of lifting tables and the effect of a load control device

Situation of lifting table	Stationary Down	Lifting from Down	Stationary Up	Lowering from Up
Possibility of overload	Yes	Yes	Yes	Yes
Consequences of overload	Possible platform damage	Structural damage	Structural damage	Structural damage
Effect of Load control device	No effect	Prevents overload	No effect	No effect
Clause in this standard	No device possible	5.7.11, 5.7.12, 5.8.4; 5.9.4	No device possible	No device possible

The examples given in table A.1, show that in the majority of cases, hazards cannot be fully avoided by using
a load control device.

For hydraulic and pneumatic lifting tables pressure relief valves (see 5.8.4 and 5.9.4) can prevent excessive
overload (plus 10 %, plus or minus 5 %) when lifting loads from a "down" position.

This pressure normally varies during the ascent and cannot be used as an accurate, and all height, load
control device.

With the present "state of art" an accurate, cost effective and reliable load control device for all positions of the
lifting table is not available.

The instructions for use delivered with each lifting table includes information on the rated load and the method
of loading and securing this load.
Since many lifting tables are series production models, the final use of which is not known by the manufacturer, the "information for use" contains requirements concerning the residual risk of overloading.

Annex B

#(normative)

Noise

Generally noise is not considered to be a significant hazard for this type of machinery. Therefore there is no
special test method for noise in this European Standard.
The following information on airborne noise emissions shall be specified in the information for use:
| the A-weighted emission sound pressure level at workstations, where this exceeds 70 dB(A); where this
level does not exceed 70 dB(A), this fact shall be indicated.
These values shall be either those actually measured for the lifting table in question or those established on
the basis of measurements taken for a technically comparable lifting table which is representative of the lifting
table to be produced.
Where the harmonised standards are not applied, sound levels shall be measured using the most appropriate
method for the machinery. Whenever sound emission values are indicated the uncertainties surrounding these
values shall be specified. The operating conditions of the machinery during measurement and the measuring
methods used shall be described.
Where the workstation(s) are undefined or cannot be defined, A-weighted sound pressure levels shall be
measured at a distance of 1 m from the surface of the machinery and at a height of 1,6 m from the floor or
access platform. The position and value of the maximum sound pressure shall be indicated.
NOTE Information on noise emission should also be provided in the sales literature.$

Annex C

(normative)

Test procedures

C.1 Practical tests for Type Testing Procedures

a) Check the correct operation of the controls;

b) Check that the emergency stop and other safety devices (if fitted) are correctly functioning;
c) Operate the unloaded lifting table through one complete cycle;
d) Place the rated load distributed as specified by the manufacturer, on the lifting platform and operate the
lifting table through one complete cycle. (Where applicable record the maximum operating pressure);
e) Record the time taken fully raise the platform while carrying the rated load, and the time taken to fully
lower the platform also while carrying the rated load;
f) Leave the platform, still carrying the rated load, fully raised for 10 min. Measure and record the vertical
creep of the platform in this time. This creep shall not exceed 5 mm;
g) Insert maintenance locking device under the platform carrying the rated load and check satisfactory
operation;
!
h) Increase the rated load by 10 % and operate through the number of cycles necessary to enable the
necessary record of the maximum pressure to be made;"
i) Raise the platform to the position of maximum stress on the structure and further increase the rated load
to produce a 25 % overload;
If various parts of the structure or load-bearing members reach maximum stress at different heights this test
shall be repeated at each of these heights;
This test is a static test only and it is not necessary to move the platform under this overload;
For manually operated lifting tables that are not fitted with a load limiting device, a 50 % overload shall be
used for this test;
Tests under i) can be omitted if full strain gauge tests are available;
NOTE After removing the 25 % overload, where applicable set the load limiting device to lift not more than 110 % of
the rated load and lock the device against unauthorised adjustment.
j) Test the load limiting device;
!
k) Reduce and redistribute the load in accordance with 5.1.1.7. Operate the lifting table through one complete cycle. Check that deflections and tilt are within the manufacturers specification;"

l) After removing all loads visually check (by normal vision) all parts of the lifting table for permanent deformation or damage;
m) Check satisfactory operation of braking or holding devices according to the design, where fitted;
n) Check all ancillary equipment for satisfactory operation, including interlocks where fitted;
o) Show that overturning conditions are satisfied in accordance with 5.1.2.1.

C.2 Practical tests for fitness for purpose test before despatch

a) Check the correct operation of the controls;
b) Check that the emergency stop and other safety devices (if fitted) are correctly functioning;
c) Operate the unloaded lifting table through one complete cycle;
d) Leave the platform, carrying the rated load, fully raised for 10 min. Measure and record the vertical creep
of the platform in this time. This creep shall not exceed 5 mm;
e) Insert maintenance locking device under the platform carrying the rated load and check satisfactory
operation;

f) Increase the rated load by 10 % and operate through one complete cycle (record maximum pressure);
g) Raise the platform to the position of maximum stress on the structure and further increase the rated load
to produce a 25 % overload;
If various parts of the structure or load-bearing members reach maximum stress at different heights this test
shall be repeated at each of these heights;
This test is a static test only and it is not necessary to move the platform under this overload;
For manually operated lifting tables that are not fitted with a load limiting device, a 50 % overload shall be
used for this test;
h) Test the load limiting device;
i) Check satisfactory operation of braking devices according to the design, where fitted;
j) Check all ancillary equipment for satisfactory operation, including interlocks where fitted.

C.3 !Practical tests for fitness for purpose test when the lifting table has been manufactured to an approved quality assurance system (e.g. EN ISO 9001 [2000 revision])"

a) Check the correct operation of the controls;
b) Check that the emergency stop and other safety devices (if fitted) are correctly functioning;
c) Operate the unloaded lifting table through one complete cycle;
d) Load the table with 10 % more than the rated load and operate through one complete cycle;
e) Test the load limiting device.

Annex D

!(informative)

Test certificate for lifting tables"

D.1 Description

- Manufacturer's name and address;
- Lifting table type and serial no;
- Electric power supply;
- Weather protection category - inside or outside;
- Rated load and distribution;
- Maximum working pressure;
- Pressure relief valve setting.

D.2 Tests

a) Dynamic (rated load);
load applied;
max. pressure;
raising time;
lowering time;
b) Creep (rated load for 10 min);
load applied;
creep measured;
c) Maintenance support;
satisfactory under full load;
d) Dynamic (rated load + 10 %);

load applied;
e) Static (rated + 25 %);
load applied;
f) Pressure relief valve setting;

g) Unevenly distributed load (see 5.1.1.7).
!*deleted text*"

Annex E

(informative)

Controls

In diagrams E.1. to E.8. the following nomenclature applies
1) Down
2) Up
This annex shows some methods whereby the requirements of 5.5.3, 5.5.4 and 5.5.5 can be fulfilled:
to 5.5.3:
This requirement can be fulfilled by:
a) a safety switch with a key that can only be taken out after the lift has stopped or;
b) a push-button that locks automatically and can only be released with a security key or;
c) an interlockable main switch in accordance with 5.3.2 letter a, b or c of EN 60204-1:1992.
to 5.5.4:
This requirement can be fulfilled as follows:
a) where buttons are used, if the button for the raising movement is positioned above or to the right of the
button for the lowering movement. (see figure E.1);

Figure E.1 — Arrangement of buttons

b) where foot operated buttons are used, if the button for the raising movement is positioned to the right of
the button for the lowering movement (see figure E.2);

!**Figure E.2 — Arrangement of foot-operated buttons**"

c) where horizontal levers are used,

1) if upward movement of the lever generates the raising movement and the downwards movement of
the lever generates the lowering movement (see figure E.3);

Figure E.3 — Up down and down movement of horizontal levers

2) if the movement of the lever to the right generates the raising movement and the movement of the

lever to the left generates the lowering movement (see figure E.4);

Figure E.4 — Left and right movement of horizontal levers

d) where vertical levers are used, if the movement of the lever towards the human body generates the
raising movement and the movement of the lever away from the human body generates the lowering movement (see figure E.5);

Figure E.5 — Movement of vertical levers

e) where pedals are used, if the pedal for the raising movement is on the right and the pedal for the lowering
movement on the left (see figure E.6);

Figure E.6 — Arrangement of pedals

f) where hand wheels are used, if turning the wheel to the right starts the raising movement and turning it to
the left starts the lowering movement (see figure E.7);

Figure E.7 — Movement of hand wheels

g) all other methods of control shall use the same principles as above
to 5.5.5
This requirement can be fulfilled as follows:
a) Push-buttons: the button should not be larger than is necessary for it to be operated by one finger of a
hand wearing a protective glove. A ring shall surround the button, with minimal clearance, and no part of
the button should protrude above the ring.
b) Foot operated buttons: the space above the button should be completely covered. The distance between
the button and the cover shall be approximately 70 mm. A rectangular tubular section approximately 15 mm high should surround the button to protect it from access from the sides (see figure E.8)).
Dimensions in millimetres

Figure E.8 — Covering of foot operated buttons

c) Hand levers: an unlocking action should be necessary before operation.
d) Handwheels: handwheels should be round, solid and have no burrs or sharp edges.
If it is necessary to use more than one control device simultaneously to operate one motion of the lifting table
then it is sufficient if only one of them is protected against unintentional operation.

Annex F

(normative)

Manual force measurement methods

F.1 Maximum allowed forces for mobile lifting tables

The maximum manual forces required for mobile lifting table operations shall not exceed the following figures:

To start an unloaded lifting table moving from rest: 300 N
To maintain the movement of the lifting table: 200 N
To raise the loaded lifting table platform using a hand pump: 200 N
To raise the loaded lifting table platform using a foot pump: 300 N.

F.2 Conditions for test

The tests shall be carried out with a new lifting table on a smooth, dry, level, trowelled finish concrete floor in
good condition. The tests shall be carried out in an ambient temperature of between 15 ℃ and 28 ℃. The
measuring instrument used shall have a range of error of + 3 %.
The forces required are measured in accordance with the methods described below. Two tests in both the
forward and reverse directions shall be carried out and the average result recorded.

F.3 Measurement of starting force and rolling force

With the unloaded lifting table in starting position and stationary, the wheels are positioned in the direction that
they naturally take when moving the table in the test direction.
The force shall be applied horizontally along the table's axis, on the handle or bar in the test direction.

F.4 Starting force

The maximum value necessary to start the table moving shall be recorded.

F.5 Rolling force

The maximum value necessary to maintain the table at a stabilised speed of 0,5 m/s shall be recorded.

F.6 Average forces

The maximum starting force or the maximum rolling force is the average of the maximum values recorded in
each direction of travel, forward and reverse, during two successive tests.

F.7 !Hand or foot forces

Actuate the handle or foot pedal as many times as necessary to raise the fully loaded platform to its maximum
height.
The maximum force value is measured perpendicularly to the handle or pedal during each pumping cycle.
The maximum force value is the average of the maximum values recorded at each handle or pedal cycle
during one complete lifting."

Annex ZA

(informative)

#Relationship between this European Standard and the Essential Requirements of EU Directive 98/37/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission
and the European Free Trade Association to provide a means of conforming to Essential Requirements of the
New Approach Directive Machinery 98/37/EC, amended by 98/79/EC.
Once this standard is cited in the Official Journal of the European Communities under that Directive and has
been implemented as a national standard in at least one Member State, compliance with the normative
clauses of this standard confers, within the limits of the scope of this standard, a presumption of conformity
with the relevant Essential Requirements of that Directive and associated EFTA regulations.

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within
the scope of this standard.$

Annex ZB

(informative)

#Relationship between this European Standard and the Essential Requirements of EU Directive 2006/42/EC

This European Standard has been prepared under a mandate given to CEN by the European Commission
and the European Free Trade Association to provide a means of conforming to Essential Requirements of the
New Approach Directive Machinery 2006/42/EC.
Once this standard is cited in the Official Journal of the European Communities under that Directive and has
been implemented as a national standard in at least one Member State, compliance with the normative
clauses of this standard confers, within the limits of the scope of this standard, a presumption of conformity
with the relevant Essential Requirements of that Directive and associated EFTA regulations.

WARNING — Other requirements and other EU Directives may be applicable to the product(s) falling within
the scope of this standard.$

BS EN 1570:1998+A2:2009

EN 1570:1998+A2:2009 (E)

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2. ΑΝΑΛΥΤΙΚΑ ΑΠΟΤΕΛΕΣΜΑΤΑ ΣΤΑΤΙΚΩΝ ΕΛΕΓΧΩΝ

2.1. Μελέτη στην κατώτατη θέση λειτουργίας

Stress analysis of Assem2

1. Introduction

Summarize the FEM analysis on Assem2

Note:
Do not base your design decisions solely on the data presented in this report. Use this information in conjunction with experimental data and practical experience. Field testing is mandatory to validate your final design. COSMOSWorks helps you reduce your time-to-market by reducing but not eliminating field tests.

2. File Information

Model name: Assem2

Model location:

Results location: H:\DOCUME~1\Babis\LOCALS~1\Temp

Study name: Study 1 (-Default-)

3. Materials

No.	Part Name	Material	Mass	Volume
1	Imported-1	Cast Carbon Steel (SN)	16.731 kg	0.002145 m^3
2	Imported1-1	Cast Carbon Steel (SN)	16.731 kg	0.002145 m^3
3	Imported10-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
4	Imported11-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
5	Imported12-1	Cast Carbon Steel (SN)	3.49396 kg	0.000447944 m^3
6	Imported13-1	Cast Carbon Steel (SN)	3.49396 kg	0.000447944 m^3
7	Imported14-1	Brass	0.0649889 kg	7.64576e-006 m^3
8	Imported15-1	Brass	0.0649889 kg	7.64576e-006 m^3
9	Imported16-1	Cast Carbon Steel (SN)	1.56828 kg	0.000201062 m^3
10	Imported17-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
11	Imported18-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
12	Imported19-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
13	Imported2-1	Cast Carbon Steel (SN)	4.719 kg	0.000605 m^3
14	Imported20-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
15	Imported21-	Cast Carbon Steel	9.51987 kg	0.0012205 m^3

	1	(SN)		
16	Imported22-1	Cast Carbon Steel (SN)	9.51987 kg	0.0012205 m^3
17	Imported23-1	Cast Carbon Steel (SN)	3.33899 kg	0.000428076 m^3
18	Imported24-1	Cast Carbon Steel (SN)	3.33899 kg	0.000428076 m^3
19	Imported25-1	Cast Carbon Steel (SN)	9.38789 kg	0.00120358 m^3
20	Imported26-1	Cast Carbon Steel (SN)	1.53752 kg	0.000197118 m^3
21	Imported27-1	Cast Carbon Steel (SN)	1.53752 kg	0.000197118 m^3
22	Imported28-1	Cast Carbon Steel (SN)	82.4938 kg	0.0105761 m^3
23	Imported29-1	Cast Carbon Steel (SN)	1.72228 kg	0.000220805 m^3
24	Imported3-1	Cast Carbon Steel (SN)	4.719 kg	0.000605 m^3
25	Imported30-1	Cast Carbon Steel (SN)	1.72228 kg	0.000220805 m^3
26	Imported31-1	Cast Carbon Steel (SN)	1.72228 kg	0.000220805 m^3
27	Imported32-1	Cast Carbon Steel (SN)	1.72228 kg	0.000220805 m^3
28	Imported4-1	Cast Carbon Steel (SN)	0.750448 kg	9.62113e-005 m^3
29	Imported5-1	Cast Carbon Steel (SN)	0.750448 kg	9.62113e-005 m^3
30	Imported6-1	Cast Carbon Steel (SN)	0.750448 kg	9.62113e-005 m^3
31	Imported7-1	Cast Carbon Steel (SN)	0.750448 kg	9.62113e-005 m^3
32	Imported8-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
33	Imported9-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3

4. Load & Restraint Information

Restraint		
Restraint-1 <Imported-1, Imported2-1, Imported1-1, Imported3-1>	on **4 Face(s)** fixed.	
Description:		
Restraint-2 <Imported17-1, Imported9-1, Imported18-1, Imported8-1, Imported20-1, Imported11-1, Imported10-1, Imported19-1>	on **16 Face(s)**Hinge	
Description:		

Load		
Force-1 <Imported28-1>	on **1 Face(s)** apply normal force **10000 N** using uniform distribution	Sequential Loading
Description:		
Gravity-1	Gravity with respect to **Edge< 1 >** with gravity acceleration **-9.81 m/s^2** normal to reference plane	Sequential Loading
Description:		

5. Study Property

Mesh Information	
Mesh Type:	Solid mesh
Mesher Used:	Standard
Automatic Transition:	Off
Smooth Surface:	On
Jacobian Check:	4 Points
Element Size:	17.618 mm
Tolerance:	0.8809 mm
Quality:	High
Number of elements:	119046
Number of nodes:	226837
Time to complete mesh(hh;mm;ss):	00:00:54
Computer name:	BABISHOMEPC

Solver Information	
Quality:	High
Solver Type:	FFEPlus
Option:	Include Thermal Effects
Thermal Option:	Input Temperature
Thermal Option:	Reference Temperature at zero strain: 298 Kelvin

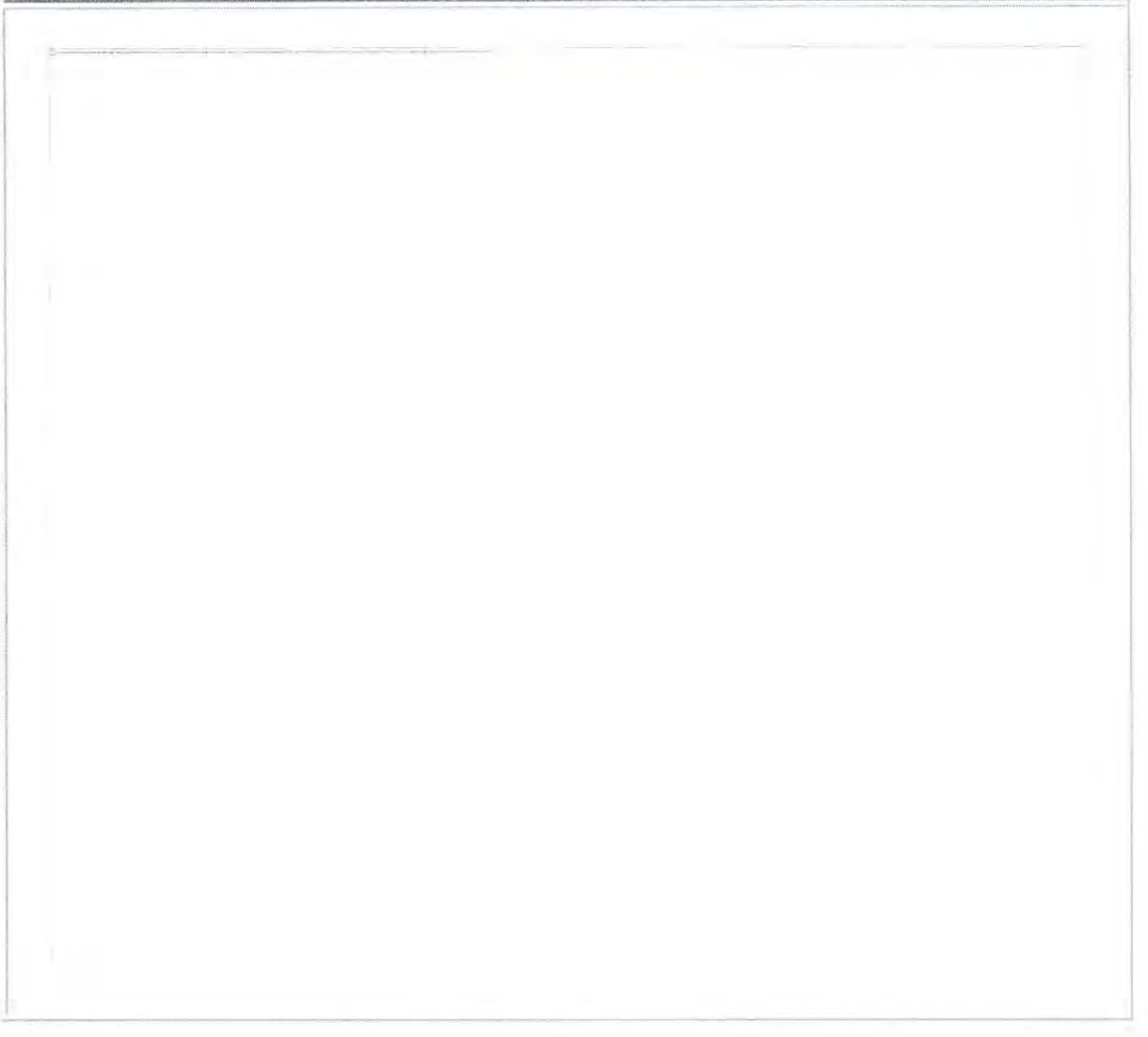
7. Results

7a. Default Results

Name	Type	Min	Location	Max	Location
Stress1	VON: von Mises stress	12.8145 N/m^2 Node: 213576	(1955 mm, 486.954 mm, -35 mm)	7.31378e+007 N/m^2 Node: 217321	(1682.28 mm, 26.2881 mm, 153.651 mm)
Displacement1	URES: Resultant displacement	0 m Node: 10	(1930 mm, 20.0971 mm, -35 mm)	0.000589468 m Node: 191109	(710.767 mm, 141.51 mm, 211.002 mm)

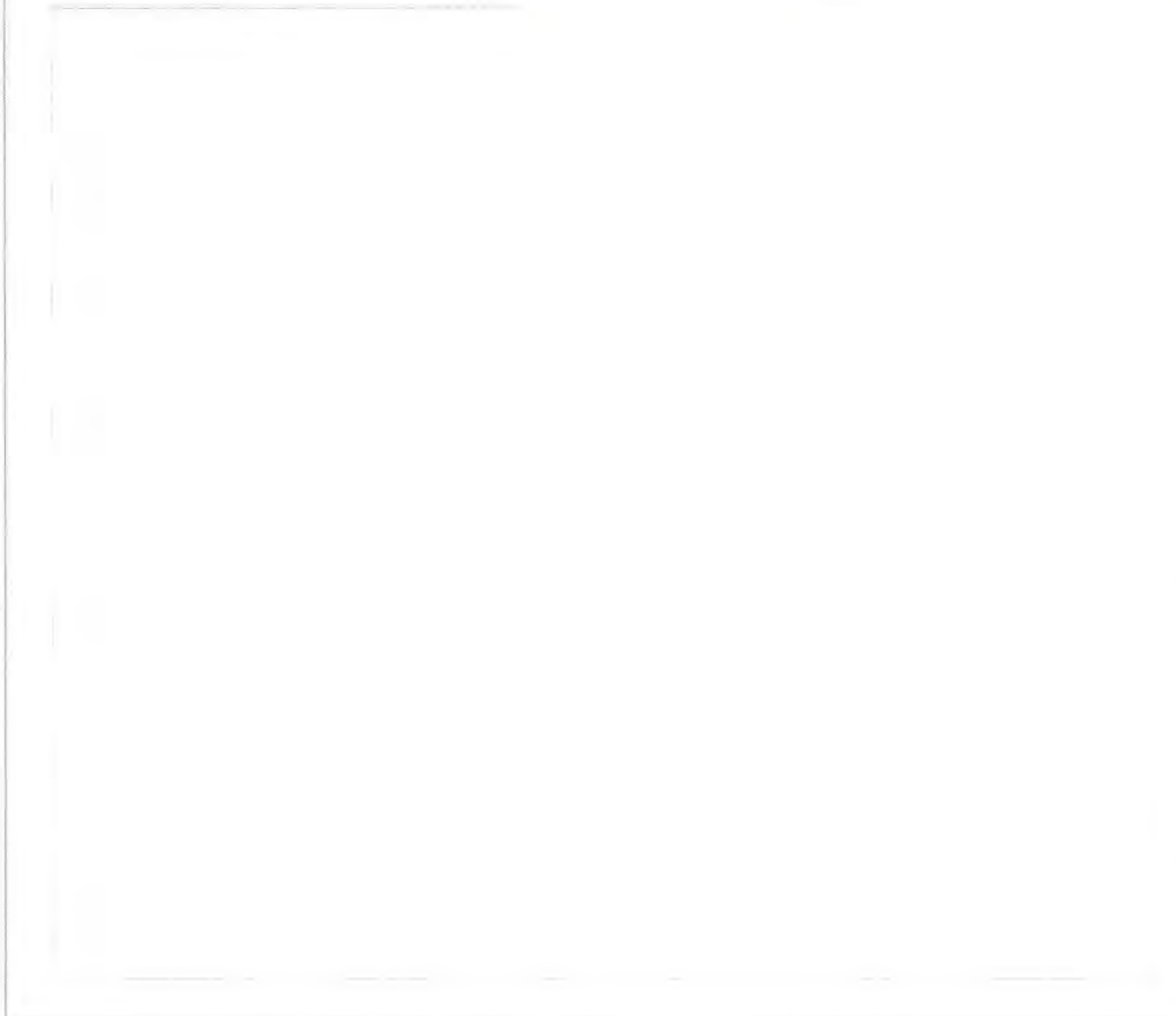
Assem2-Study 1-Design Check-Design Check1

JPEG



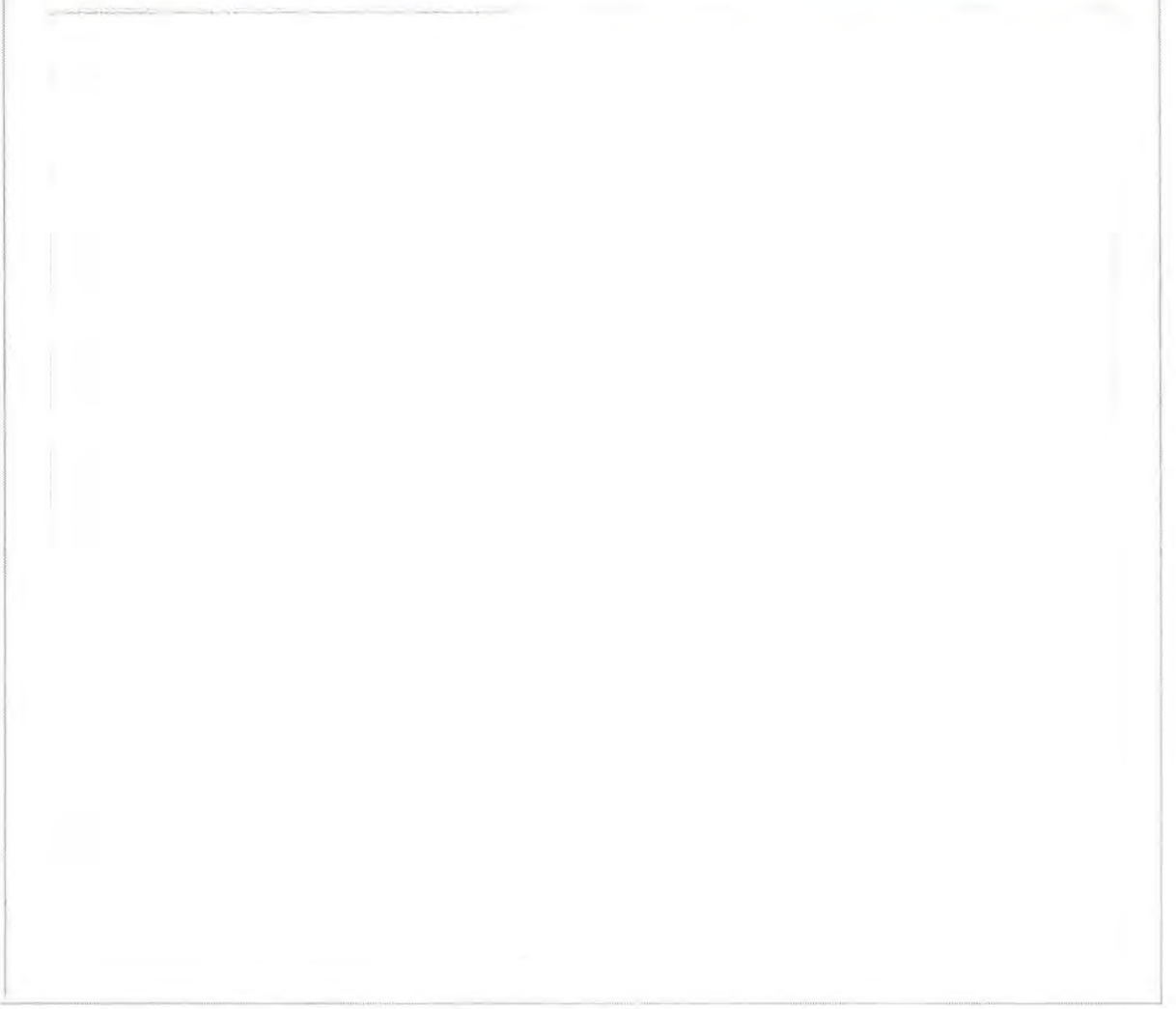
Assem2-Study 1-Stress-Stress1

JPEG



Assem2-Study 1-Displacement-Displacement1

JPEG



9. Appendix

Material name: Cast Carbon Steel (SN)

Description:

Material Source: Library files

Material Library Name: cosmos materials

Material Model Type: Linear Elastic Isotropic

Property Name	Value	Units	Value Type
Elastic modulus	2e+011	N/m^2	Constant
Poisson's ratio	0.32	NA	Constant
Shear modulus	7.6e+010	N/m^2	Constant
Mass density	7800	kg/m^3	Constant
Tensile strength	4.8255e+008	N/m^2	Constant
Yield strength	2.4817e+008	N/m^2	Constant
Thermal expansion coefficient	1.2e-005	/Kelvin	Constant
Thermal conductivity	30	W/(m.K)	Constant
Specific heat	500	J/(kg.K)	Constant

Material name: Brass

Description:

Material Source: Library files

Material Library Name: cosmos materials

Material Model Type: Linear Elastic Isotropic

Property Name	Value	Units	Value Type
Elastic modulus	1e+011	N/m^2	Constant
Poisson's ratio	0.33	NA	Constant
Shear modulus	3.7e+010	N/m^2	Constant
Mass density	8500	kg/m^3	Constant
Tensile strength	4.7841e+008	N/m^2	Constant
Yield strength	2.3969e+008	N/m^2	Constant
Thermal expansion coefficient	1.8e-005	/Kelvin	Constant
Thermal conductivity	110	W/(m.K)	Constant
Specific heat	390	J/(kg.K)	Constant

Stress analysis of ASSEM 2

1. Introduction

Summarize the FEM analysis on Assem 2

Note:
Do not base your design decisions solely on the data presented in this report. Use this information in conjunction with experimental data and practical experience. Field testing is mandatory to validate your final design. COSMOSWorks helps you reduce your time-to-market by reducing but not eliminating field tests.

2. File Information

Model name: Assem2

Model location:

Results location: H:\DOCUME~1\Babis\LOCALS~1\Temp

Study name: Study 1 (-Default-)

3. Materials

No.	Part Name	Material	Mass	Volume
1	Imported-1	Cast Carbon Steel (SN)	16.731 kg	0.002145 m^3
2	Imported1-1	Cast Carbon Steel (SN)	16.731 kg	0.002145 m^3
3	Imported10-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
4	Imported11-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
5	Imported12-1	Cast Carbon Steel (SN)	3.49396 kg	0.000447944 m^3
6	Imported13-1	Cast Carbon Steel (SN)	3.49396 kg	0.000447944 m^3
7	Imported14-1	Brass	0.0649889 kg	7.64576e-006 m^3
8	Imported15-1	Brass	0.0649889 kg	7.64576e-006 m^3
9	Imported16-1	Cast Carbon Steel (SN)	1.56828 kg	0.000201062 m^3
10	Imported17-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
11	Imported18-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
12	Imported19-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
13	Imported2-1	Cast Carbon Steel (SN)	4.719 kg	0.000605 m^3

14	Imported20-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
15	Imported21-1	Cast Carbon Steel (SN)	9.51987 kg	0.0012205 m^3
16	Imported22-1	Cast Carbon Steel (SN)	9.51987 kg	0.0012205 m^3
17	Imported23-1	Cast Carbon Steel (SN)	3.33899 kg	0.000428076 m^3
18	Imported24-1	Cast Carbon Steel (SN)	3.33899 kg	0.000428076 m^3
19	Imported25-1	Cast Carbon Steel (SN)	9.38789 kg	0.00120358 m^3
20	Imported26-1	Cast Carbon Steel (SN)	1.53752 kg	0.000197118 m^3
21	Imported27-1	Cast Carbon Steel (SN)	1.53752 kg	0.000197118 m^3
22	Imported28-1	Cast Carbon Steel (SN)	82.4938 kg	0.0105761 m^3
23	Imported29-1	Cast Carbon Steel (SN)	1.72228 kg	0.000220805 m^3
24	Imported3-1	Cast Carbon Steel (SN)	4.719 kg	0.000605 m^3
25	Imported30-1	Cast Carbon Steel (SN)	1.72228 kg	0.000220805 m^3
26	Imported31-1	Cast Carbon Steel (SN)	1.72228 kg	0.000220805 m^3
27	Imported32-1	Cast Carbon Steel (SN)	1.72228 kg	0.000220805 m^3
28	Imported4-1	Cast Carbon Steel (SN)	0.750448 kg	9.62113e-005 m^3
29	Imported5-1	Cast Carbon Steel (SN)	0.750448 kg	9.62113e-005 m^3
30	Imported6-1	Cast Carbon Steel (SN)	0.750448 kg	9.62113e-005 m^3
31	Imported7-1	Cast Carbon Steel (SN)	0.750448 kg	9.62113e-005 m^3
32	Imported8-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
33	Imported9-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3

4. Load & Restraint Information

Restraint	
Restraint-1 <Imported-1, Imported2-1, Imported1-1, Imported3-1>	on **4 Face(s)** fixed.
Description:	
Restraint-2 <Imported18-1, Imported8-1, Imported17-1, Imported9-1, Imported10-1, Imported11-1, Imported19-1, Imported20-1>	on **16 Face(s)**Hinge
Description:	

Load		
Force-1 <Imported28-1>	on **1 Face(s)** apply normal force **10000 N** using uniform distribution	Sequential Loading
Description:		
Gravity-1	Gravity with respect to **Edge< 1 >** with gravity acceleration **-9.81 m/s^2** normal to reference plane	Sequential Loading
Description:		

5. Study Property

Mesh Information	
Mesh Type:	Solid mesh
Mesher Used:	Standard
Automatic Transition:	Off
Smooth Surface:	On
Jacobian Check:	4 Points
Element Size:	18.401 mm
Tolerance:	0.92005 mm

Quality:	High
Number of elements:	109249
Number of nodes:	207937
Time to complete mesh(hh;mm;ss):	00:00:50
Computer name:	BABISHOMEPC

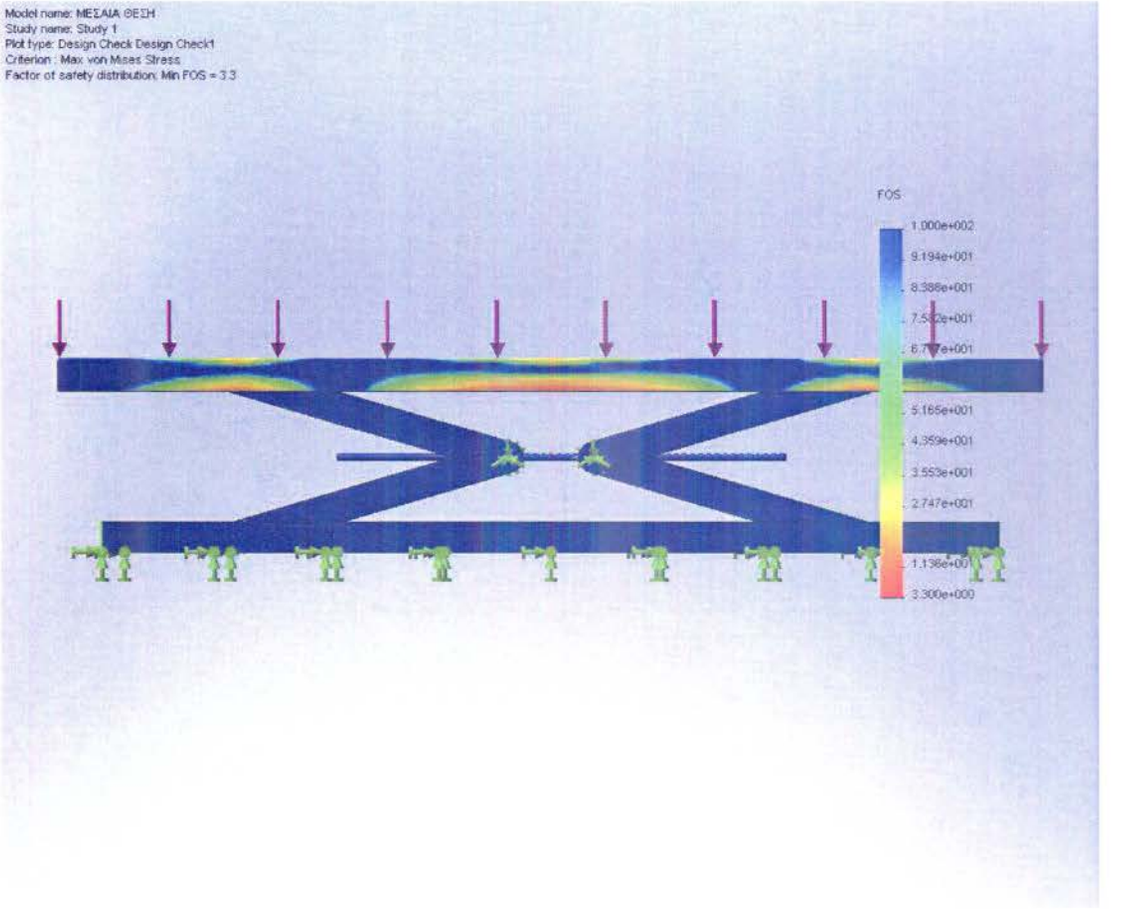
Solver Information	
Quality:	High
Solver Type:	FFEPlus
Option:	Include Thermal Effects
Thermal Option:	Input Temperature
Thermal Option:	Reference Temperature at zero strain: 298 Kelvin

7a. Default Results

Name	Type	Min	Location	Max	Location
Stress1	VON: von Mises stress	13.3935 N/m^2 Node: 3491	(658 mm, -4.90291 mm, -35 mm)	6.98838e+007 N/m^2 Node: 198969	(1682.28 mm, 25.9341 mm, 342.617 mm)
Displacement1	URES: Resultant displacement	0 m Node: 10	(1930 mm, 20.0971 mm, -35 mm)	0.000578631 m Node: 174669	(720.138 mm, 144.729 mm, 399.967 mm)

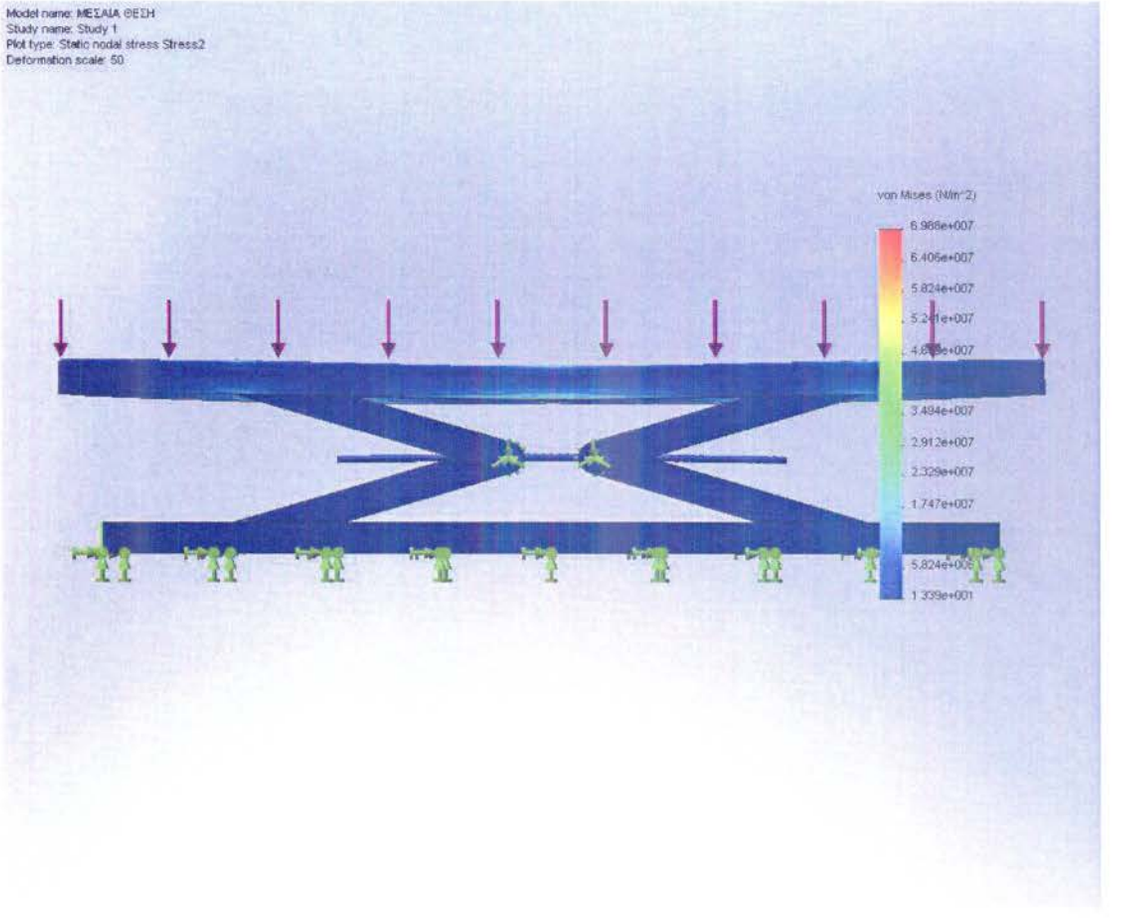
Assem2-Study 1-Design Check-Design Check1

JPEG



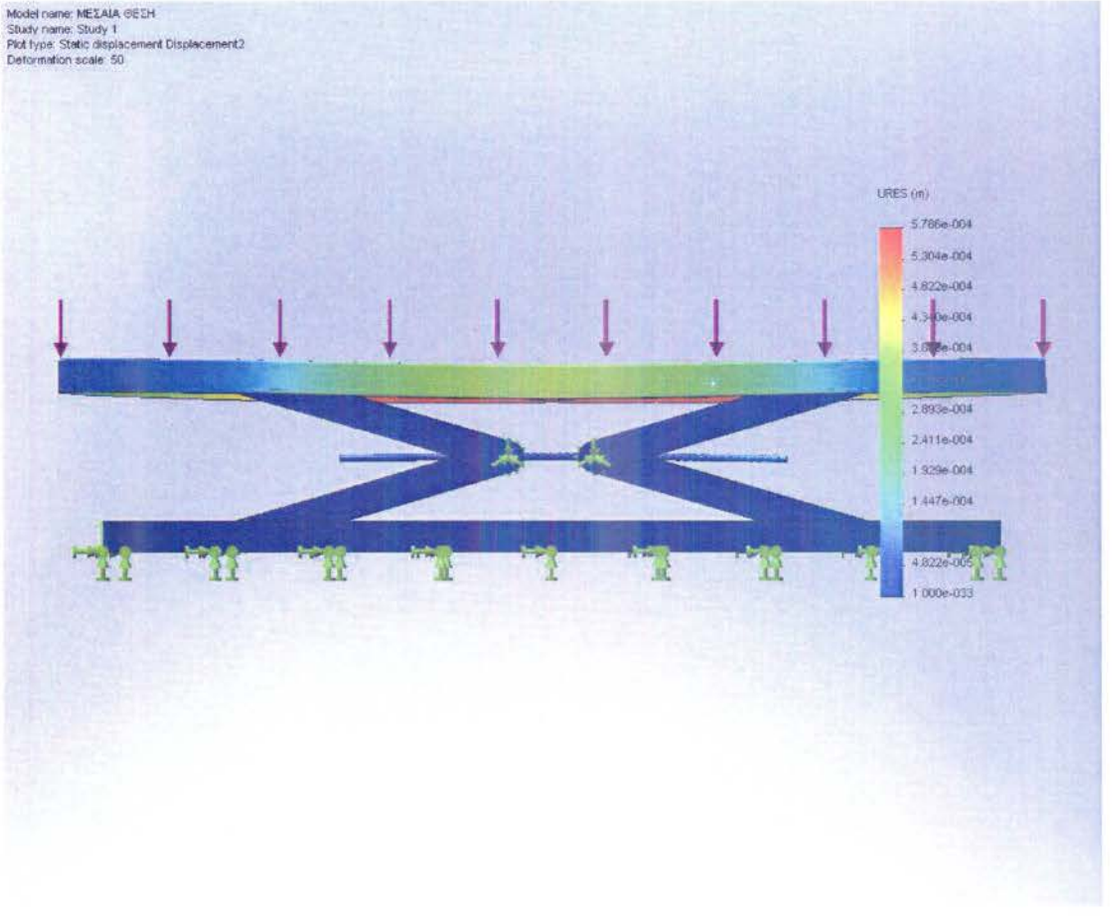
Assem2-Study 1-Stress-Stress1

JPEG



Assem2-Study 1-Displacement-Displacement1

JPEG



9. Appendix

Material name: Cast Carbon Steel (SN)

Description:

Material Source: Library files

Material Library Name: cosmos materials

Material Model Type: Linear Elastic Isotropic

Property Name	Value	Units	Value Type
Elastic modulus	2e+011	N/m^2	Constant
Poisson's ratio	0.32	NA	Constant
Shear modulus	7.6e+010	N/m^2	Constant
Mass density	7800	kg/m^3	Constant
Tensile strength	4.8255e+008	N/m^2	Constant
Yield strength	2.4817e+008	N/m^2	Constant
Thermal expansion coefficient	1.2e-005	/Kelvin	Constant
Thermal conductivity	30	W/(m.K)	Constant
Specific heat	500	J/(kg.K)	Constant

Material name: Brass

Description:

Material Source: Library files

Material Library Name: cosmos materials

Material Model Type: Linear Elastic Isotropic

Property Name	Value	Units	Value Type
Elastic modulus	1e+011	N/m^2	Constant
Poisson's ratio	0.33	NA	Constant
Shear modulus	3.7e+010	N/m^2	Constant
Mass density	8500	kg/m^3	Constant
Tensile strength	4.7841e+008	N/m^2	Constant
Yield strength	2.3969e+008	N/m^2	Constant
Thermal expansion coefficient	1.8e-005	/Kelvin	Constant
Thermal conductivity	110	W/(m.K)	Constant
Specific heat	390	J/(kg.K)	Constant

Stress analysis of Assem4

1. Introduction

Summarize the FEM analysis on Assem4

Note:
Do not base your design decisions solely on the data presented in this report. Use this information in conjunction with experimental data and practical experience. Field testing is mandatory to validate your final design. COSMOSWorks helps you reduce your time-to-market by reducing but not eliminating field tests.

2. File Information

Model name: Assem4

Model location:

Results location: H:\DOCUME~1\Babis\LOCALS~1\Temp

Study name: Study 1 (-Default-)

3. Materials

No.	Part Name	Material	Mass	Volume
1	Imported-1	Cast Carbon Steel (SN)	16.731 kg	0.002145 m^3
2	Imported1-1	Cast Carbon Steel (SN)	16.731 kg	0.002145 m^3
3	Imported10-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
4	Imported11-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
5	Imported12-1	Cast Carbon Steel (SN)	3.49396 kg	0.000447944 m^3
6	Imported13-1	Cast Carbon Steel (SN)	3.49396 kg	0.000447944 m^3
7	Imported14-1	Brass	0.0649889 kg	7.64576e-006 m^3
8	Imported15-1	Brass	0.0649889 kg	7.64576e-006 m^3
9	Imported16-1	Cast Carbon Steel (SN)	1.56828 kg	0.000201062 m^3
10	Imported17-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
11	Imported18-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
12	Imported19-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3

13	Imported2-1	Cast Carbon Steel (SN)	4.719 kg	0.000605 m^3
14	Imported20-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
15	Imported21-1	Cast Carbon Steel (SN)	9.51987 kg	0.0012205 m^3
16	Imported22-1	Cast Carbon Steel (SN)	9.51987 kg	0.0012205 m^3
17	Imported23-1	Cast Carbon Steel (SN)	3.33899 kg	0.000428076 m^3
18	Imported24-1	Cast Carbon Steel (SN)	3.33899 kg	0.000428076 m^3
19	Imported25-1	Cast Carbon Steel (SN)	9.38789 kg	0.00120358 m^3
20	Imported26-1	Cast Carbon Steel (SN)	1.53752 kg	0.000197118 m^3
21	Imported27-1	Cast Carbon Steel (SN)	1.53752 kg	0.000197118 m^3
22	Imported28-1	Cast Carbon Steel (SN)	82.4938 kg	0.0105761 m^3
23	Imported29-1	Cast Carbon Steel (SN)	1.72228 kg	0.000220805 m^3
24	Imported3-1	Cast Carbon Steel (SN)	4.719 kg	0.000605 m^3
25	Imported30-1	Cast Carbon Steel (SN)	1.72228 kg	0.000220805 m^3
26	Imported31-1	Cast Carbon Steel (SN)	1.72228 kg	0.000220805 m^3
27	Imported32-1	Cast Carbon Steel (SN)	1.72228 kg	0.000220805 m^3
28	Imported4-1	Cast Carbon Steel (SN)	0.750448 kg	9.62113e-005 m^3
29	Imported5-1	Cast Carbon Steel (SN)	0.750448 kg	9.62113e-005 m^3
30	Imported6-1	Cast Carbon Steel (SN)	0.750448 kg	9.62113e-005 m^3
31	Imported7-1	Cast Carbon Steel (SN)	0.750448 kg	9.62113e-005 m^3
32	Imported8-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3
33	Imported9-1	Cast Carbon Steel (SN)	7.17978 kg	0.000920485 m^3

4. Load & Restraint Information

Restraint		
Restraint-1 <Imported-1, Imported2-1, Imported1-1, Imported3-1>	on **4 Face(s)** fixed.	
Description:		
Restraint-2 <Imported18-1, Imported8-1, Imported17-1, Imported9-1, Imported19-1, Imported10-1, Imported11-1, Imported20-1>	on **16 Face(s)**Hinge	
Description:		

Load		
Force-1 <Imported28-1>	on **1 Face(s)** apply normal force **10000 N** using uniform distribution	Sequential Loading
Description:		
Gravity-1	Gravity with respect to **Edge< 1 >** with gravity acceleration **-9.81 m/s^2** normal to reference plane	Sequential Loading
Description:		

5. Study Property

Mesh Information	
Mesh Type:	Solid mesh
Mesher Used:	Standard
Automatic Transition:	Off
Smooth Surface:	On
Jacobian Check:	4 Points
Element Size:	20.75 mm
Tolerance:	1.0375 mm
Quality:	High
Number of elements:	80616
Number of nodes:	155423
Time to complete mesh(hh;mm;ss):	00:00:44
Computer name:	BABISHOMEPC

Solver Information	
Quality:	High
Solver Type:	FFEPlus
Option:	Include Thermal Effects
Thermal Option:	Input Temperature
Thermal Option:	Reference Temperature at zero strain: 298 Kelvin

7. Results

7a. Default Results

Name	Type	Min	Location	Max	Location
Stress1	VON: von Mises stress	14.7299 N/m^2 Node: 16495	(928.626 mm, 545.097 mm, -30 mm)	6.48168e+007 N/m^2 Node: 149560	(1683.41 mm, 515.472 mm, 705.543 mm)
Displacement1	URES: Resultant displacement	0 m Node: 10	(1930 mm, 20.0971 mm, -35 mm)	0.000567793 m Node: 93360	(1246.59 mm, 395.334 mm, 767.706 mm)
Strain1	ESTRN: Equivalent strain	3.18137e-010 Element: 76258	(1953.52 mm, 523.989 mm, -33.75 mm)	0.000241051 Element: 25489	(1674.81 mm, -95.1529 mm, 740.846 mm)
Stress2	VON: von Mises stress	14.7299 N/m^2 Node: 16495	(928.626 mm, 545.097 mm, -30 mm)	6.48168e+007 N/m^2 Node: 149560	(1683.41 mm, 515.472 mm, 705.543 mm)
Displacement2	URES: Resultant displacement	0 m Node: 10	(1930 mm, 20.0971 mm, -35 mm)	0.000567793 m Node: 93360	(1246.59 mm, 395.334 mm, 767.706 mm)

Assem4-Study 1-Design Check-Design Check1

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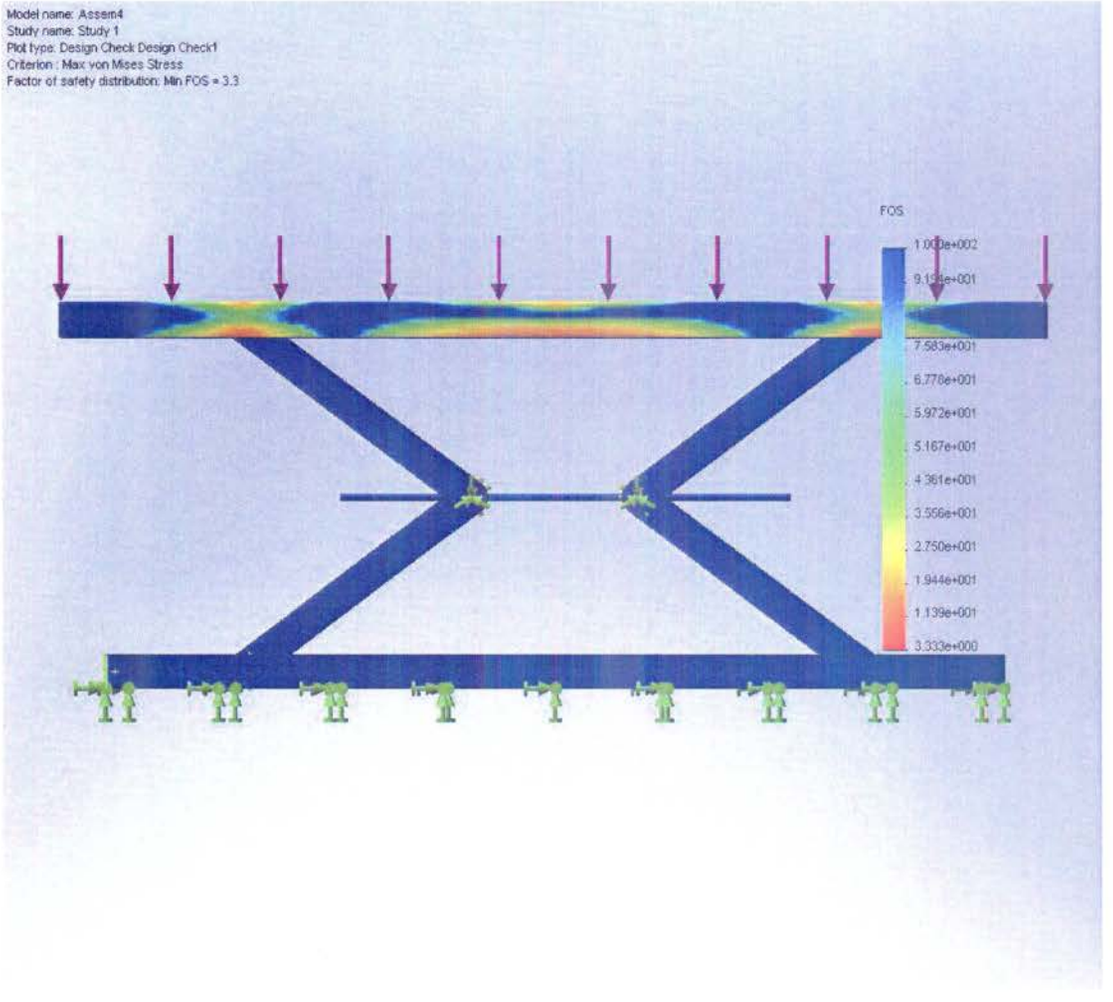

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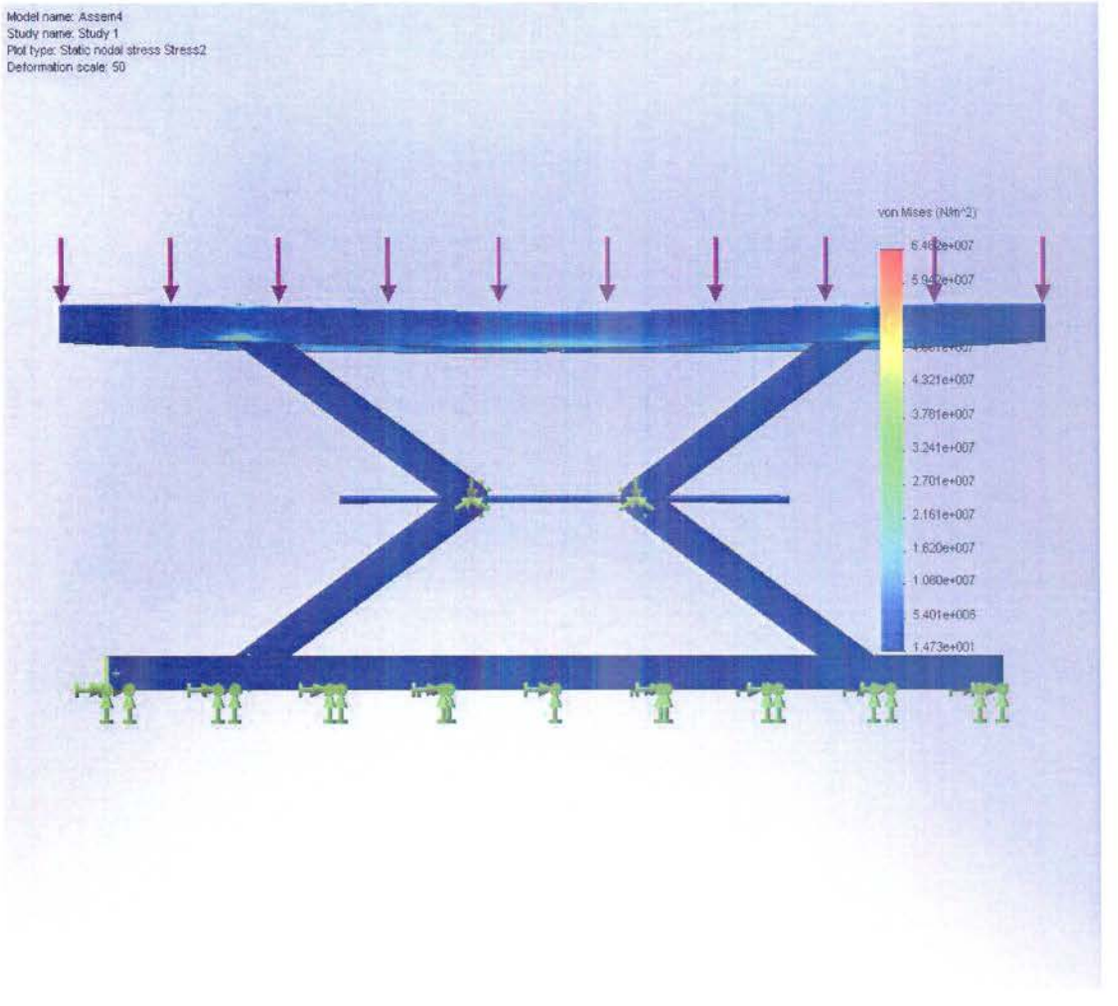

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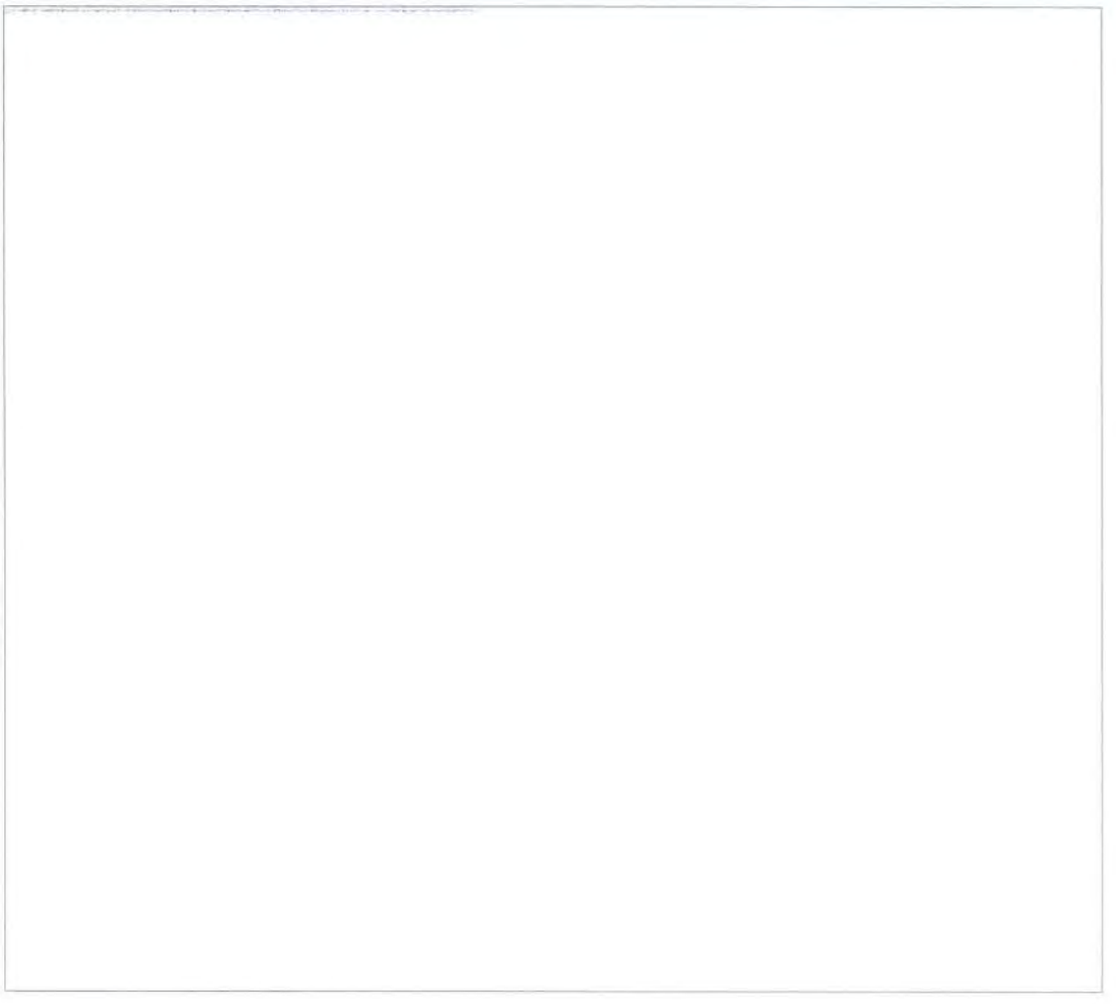


9. Appendix

Material name: Cast Carbon Steel (SN)

Description:

Material Source: Library files

Material Library Name: cosmos materials

Material Model Type: Linear Elastic Isotropic

Property Name	Value	Units	Value Type
Elastic modulus	2e+011	N/m^2	Constant
Poisson's ratio	0.32	NA	Constant
Shear modulus	7.6e+010	N/m^2	Constant
Mass density	7800	kg/m^3	Constant
Tensile strength	4.8255e+008	N/m^2	Constant
Yield strength	2.4817e+008	N/m^2	Constant
Thermal expansion coefficient	1.2e-005	/Kelvin	Constant
Thermal conductivity	30	W/(m.K)	Constant
Specific heat	500	J/(kg.K)	Constant

Material name: Brass

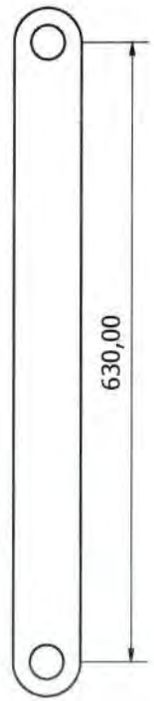
Description:

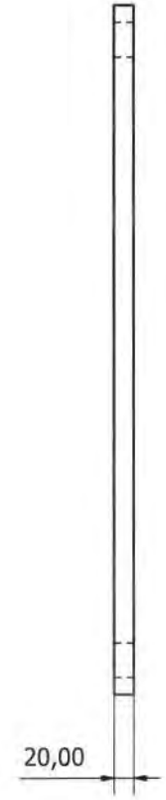
Material Source: Library files

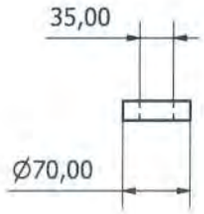
Material Library Name: cosmos materials

Material Model Type: Linear Elastic Isotropic

Property Name	Value	Units	Value Type
Elastic modulus	1e+011	N/m^2	Constant
Poisson's ratio	0.33	NA	Constant
Shear modulus	3.7e+010	N/m^2	Constant
Mass density	8500	kg/m^3	Constant
Tensile strength	4.7841e+008	N/m^2	Constant
Yield strength	2.3969e+008	N/m^2	Constant
Thermal expansion coefficient	1.8e-005	/Kelvin	Constant
Thermal conductivity	110	W/(m.K)	Constant
Specific heat	390	J/(kg.K)	Constant







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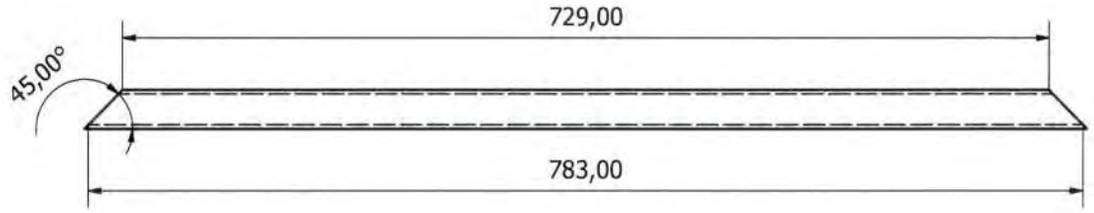
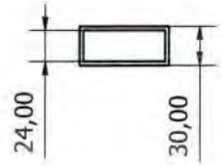
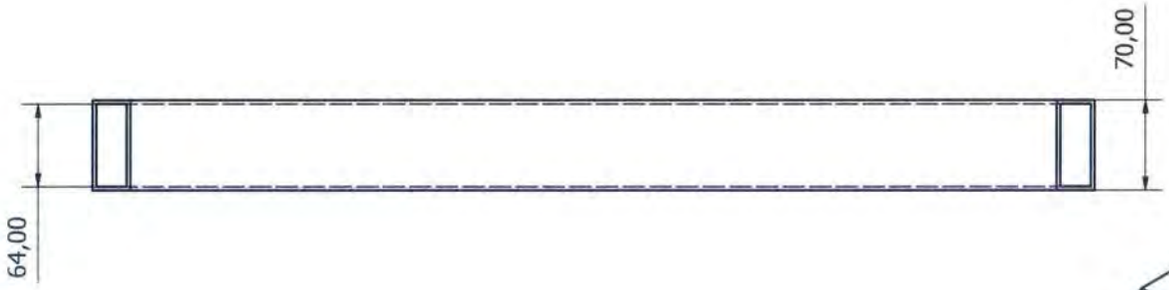
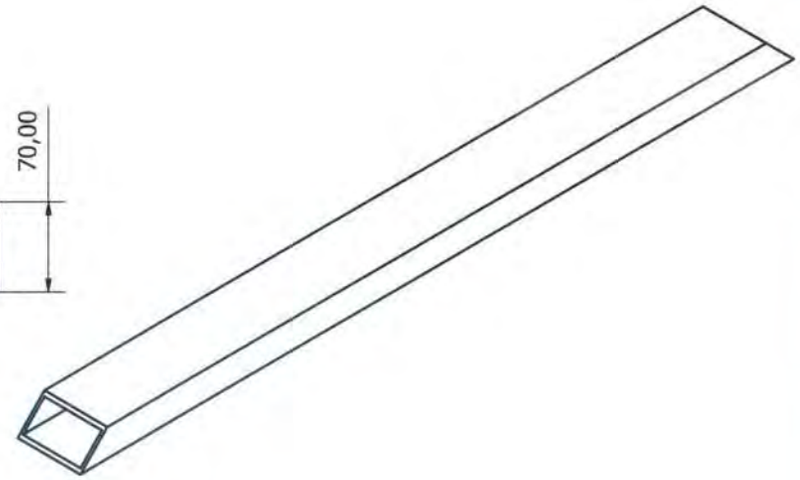
		Edition	Sheet: 1 / 1









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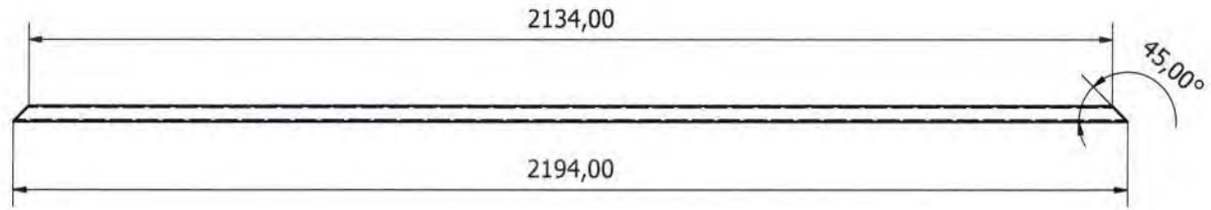

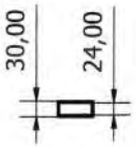

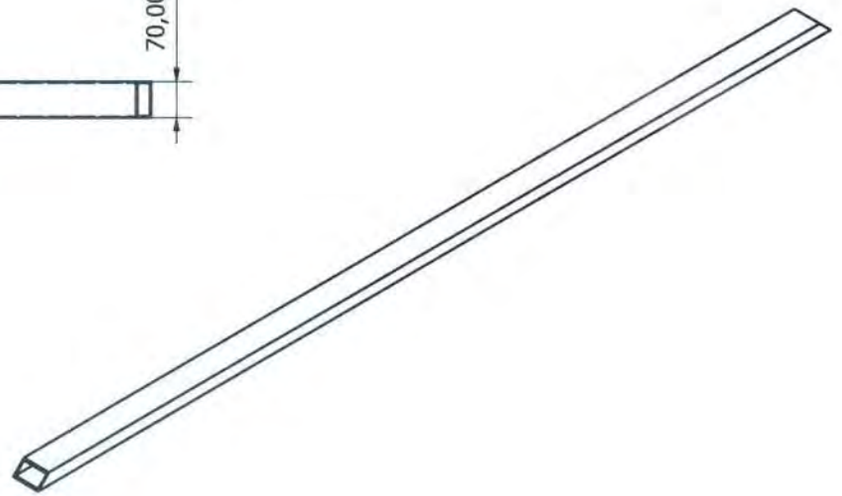

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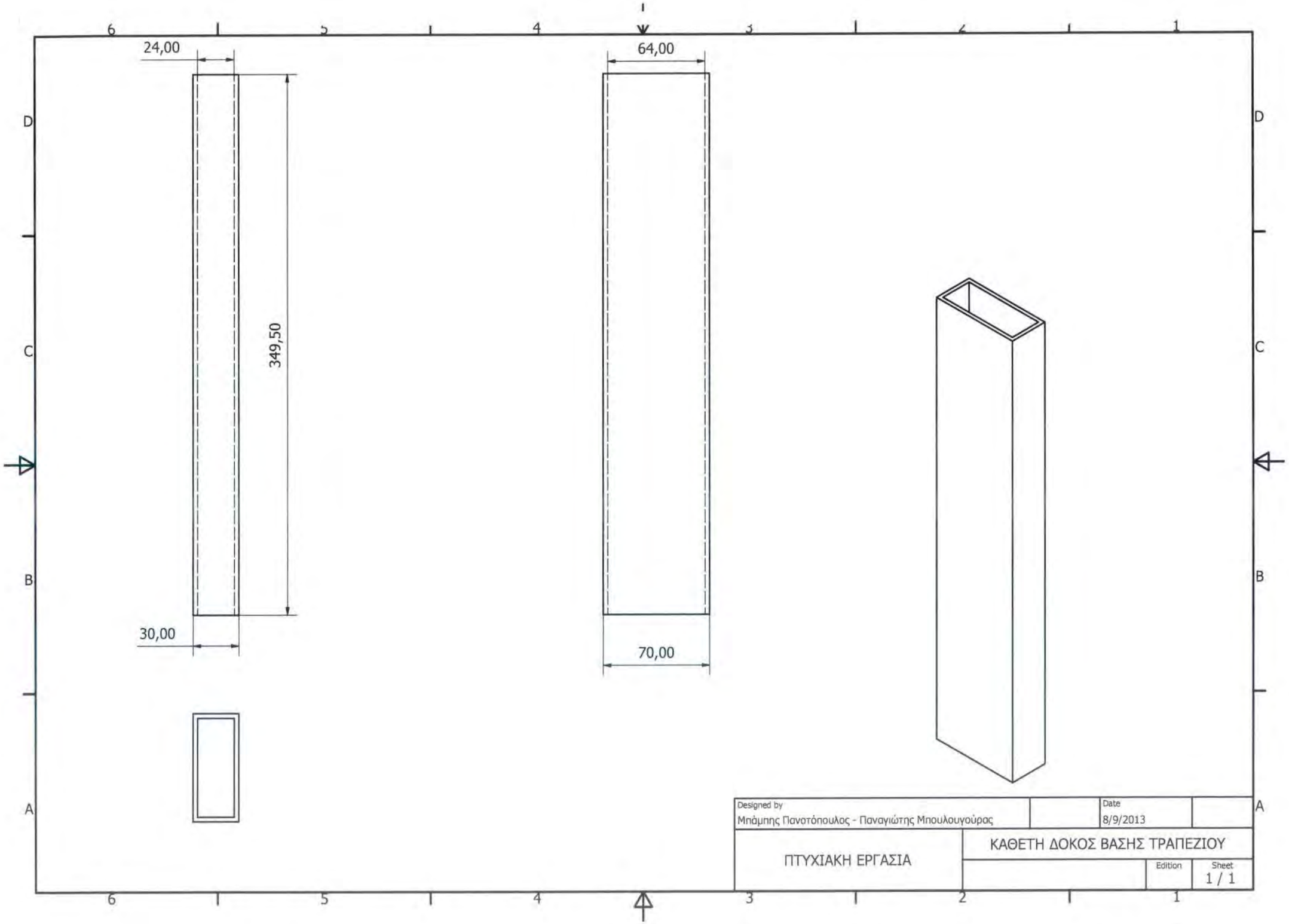

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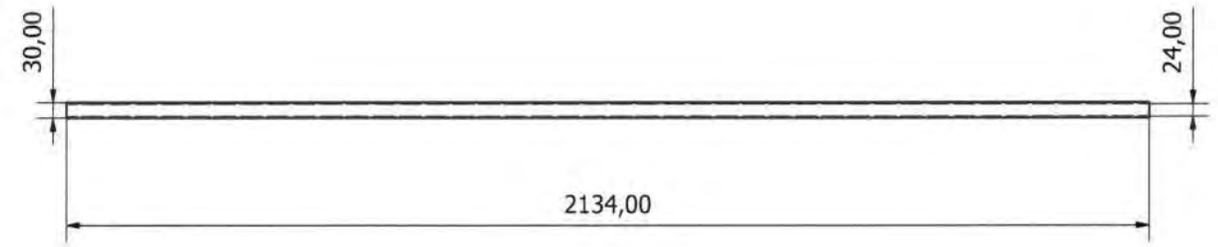

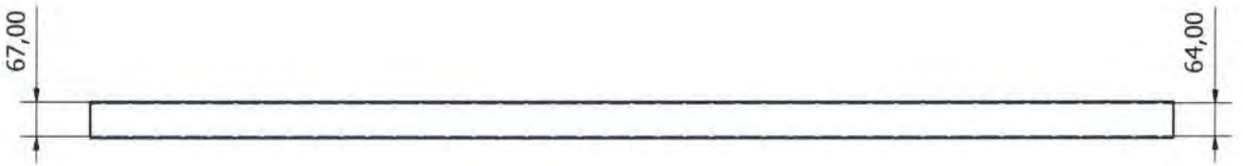

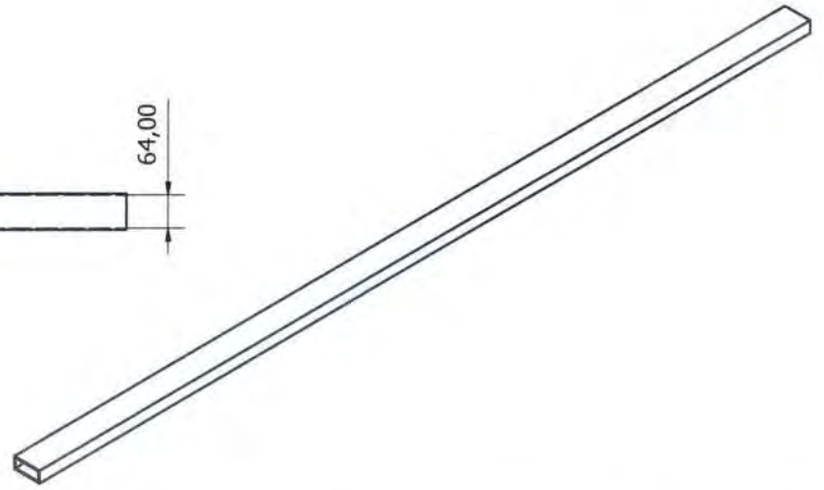

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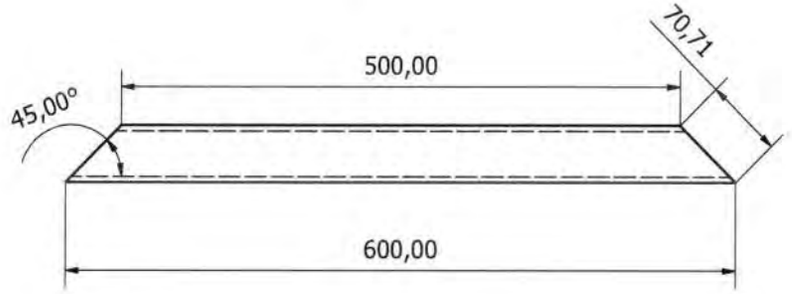

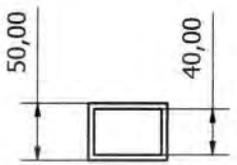

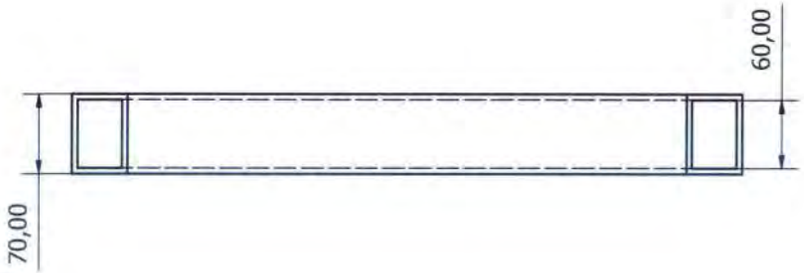

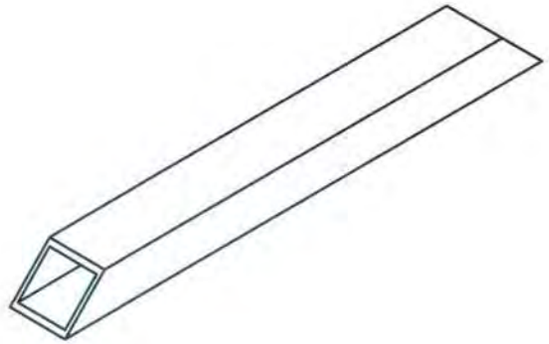

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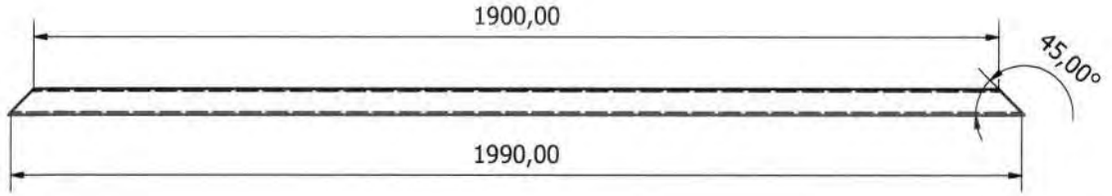

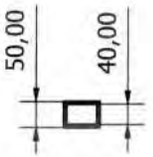

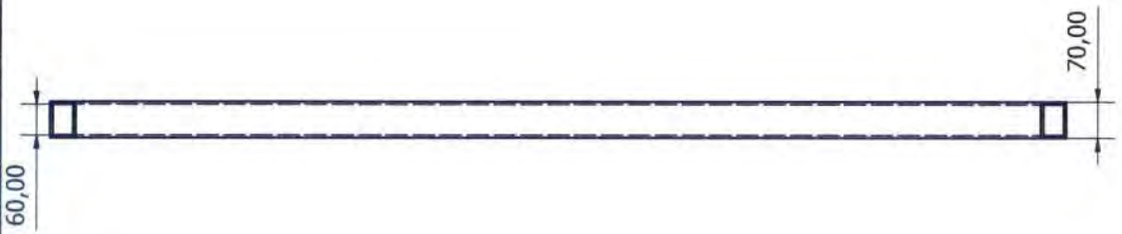

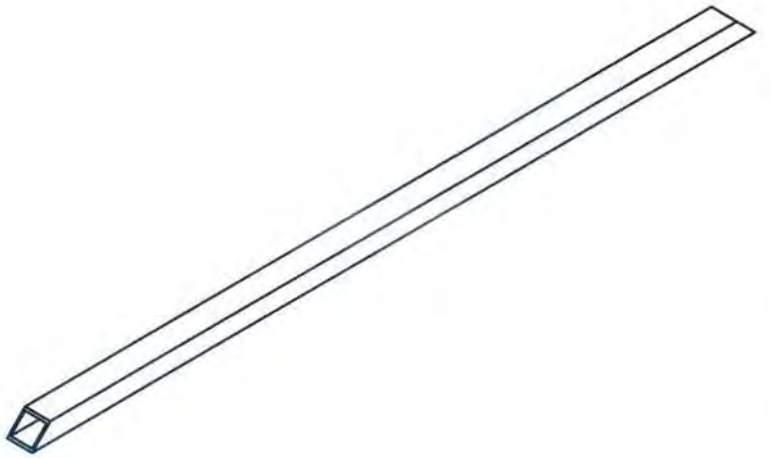

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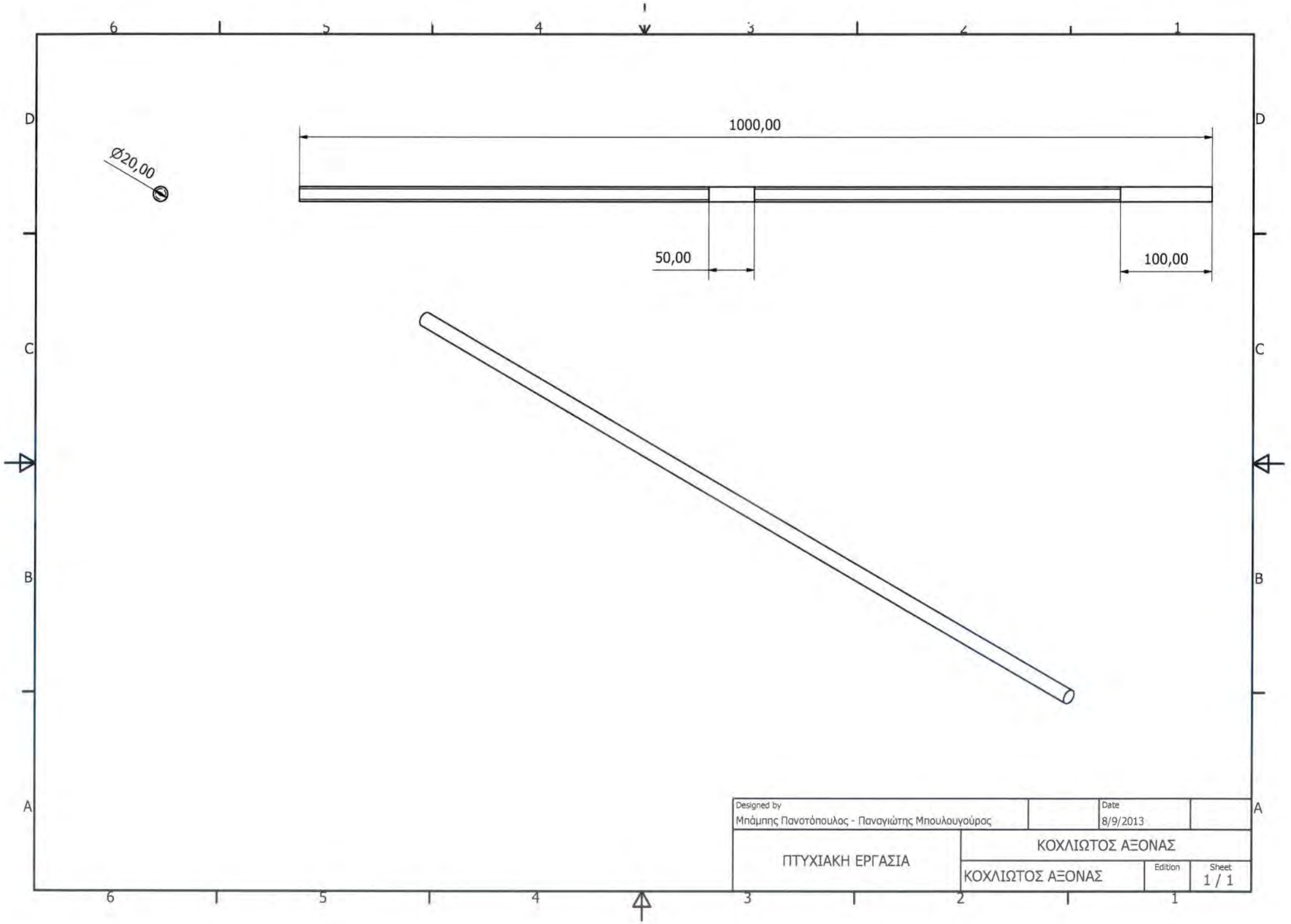

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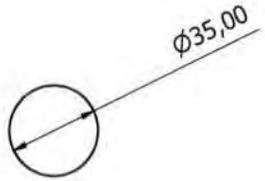

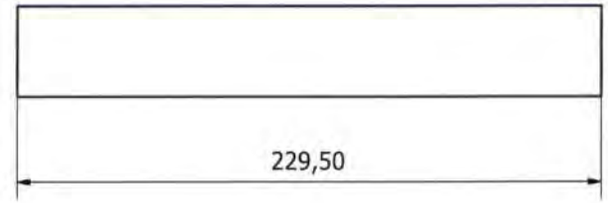

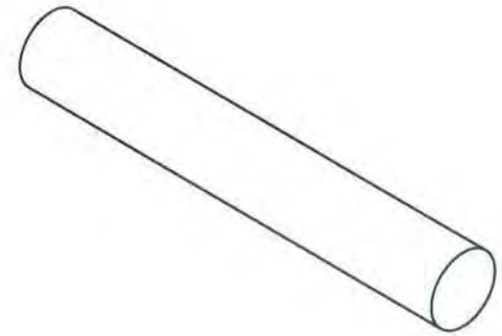

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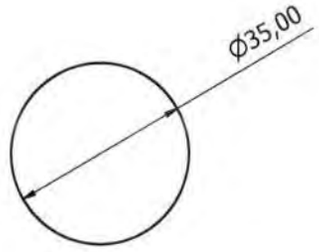

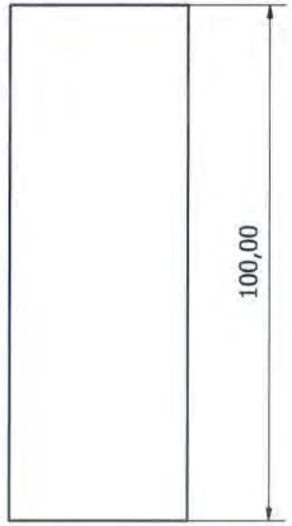

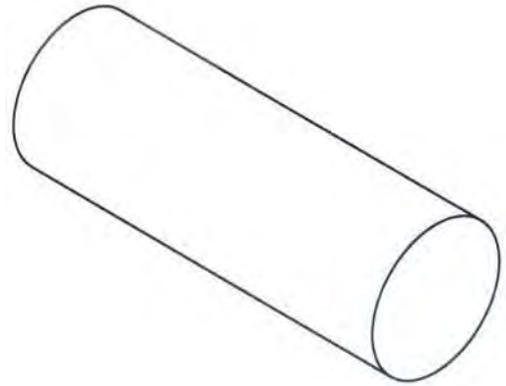

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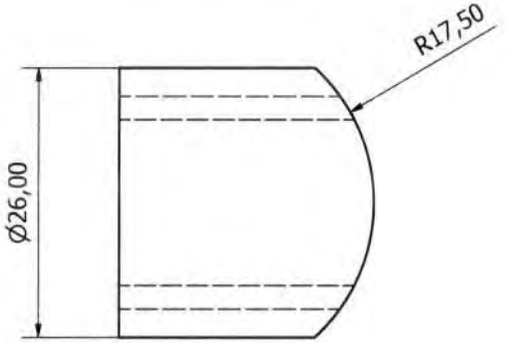

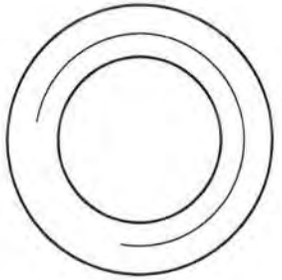

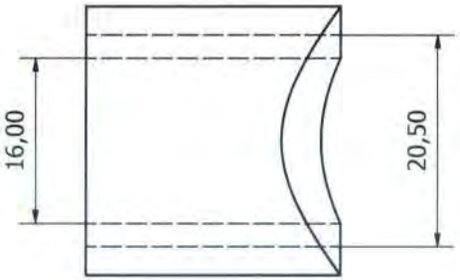

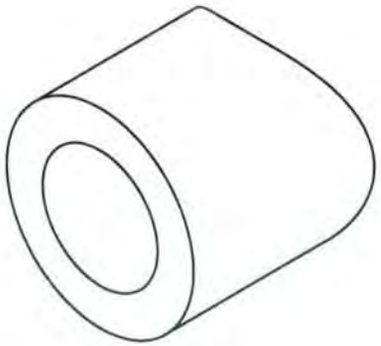

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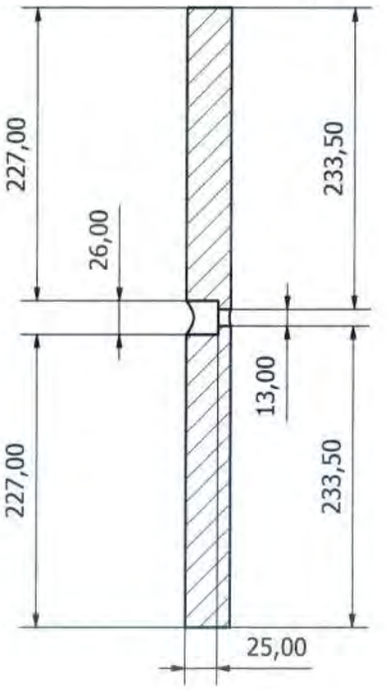

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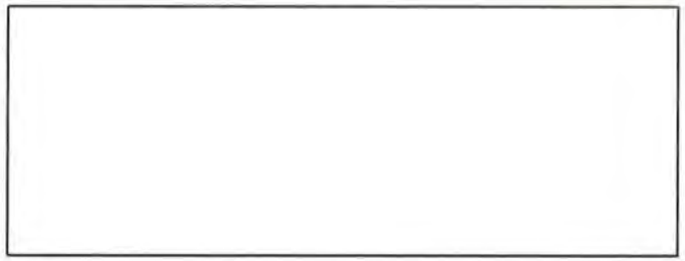

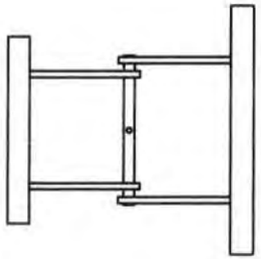

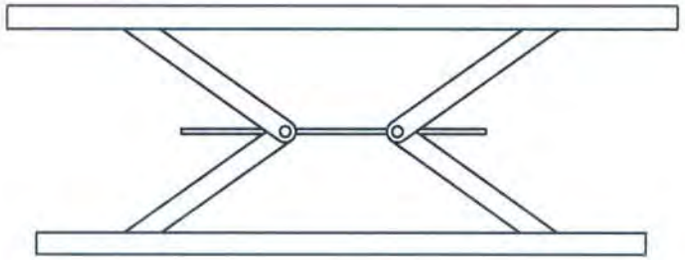

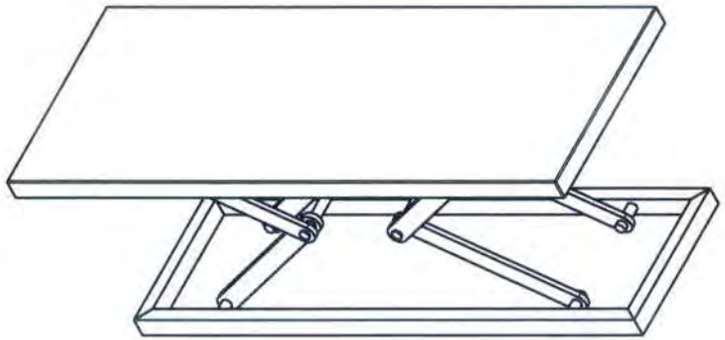

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